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TRAWL SHRIMP INDEX SURVEYS IN THE SOUTHERN DISTRICT OF THE COOK INLET MANAGEMENT AREA, SPRING 1995 AND 1997

by

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ABSTRACT

During 22 – 31 May 1995 and 27 May – 2 June 1997, the Alaska Department of Fish and Game (ADF&G) conducted trawl shrimp surveys to assess pandalid shrimp biomass in Kachemak Bay in the Southern District of the Cook Inlet Management Area. To calculate a biomass index, Kachemak Bay was apportioned into four strata. Index stations within survey strata were sampled with a 1.0-nautical mile (nmi) tow of high-rise trawl net constructed of 32-mm stretch mesh nylon. Among strata, 31 tows were completed in 1995 and 30 tows were completed in 1997. Mean catch in the 1995 survey was 41.2 lb/nmi of pandalid shrimp, yielding a biomass estimate of 443,368 ±145,593 lb. Although representing a four-fold increase from the 1993 survey, the1995 biomass estimate was the third lowest since 1977. Mean pandalid shrimp catch in 1997 was 18.8 lb/nmi, yielding a biomass estimate of 236,151 ±87,350 lb, which was a 47% decrease from the 1995 survey. Pink shrimp was the dominant shrimp species and comprised 3.6% of total biomass in 1995 and 2.6% of total biomass in 1997. The 1995 fish and non-shrimp invertebrate biomass index was the highest observed in spring shrimp index surveys. Fish composition in 1995 was dominated by walleye pollock (33.4%), flathead sole (23.7%), arrowtooth flounder (4.3%), sculpin (3.7%), and Pacific cod (2.3%). Total catch biomass in 1995 also included Tanner crab (2.4%) and Dungeness crab (0.6%). Aggregate fish and non-shrimp invertebrate catches declined 43% from the 1995 to 1997 surveys. Aggregate biomass in 1997 was dominated by flathead sole (28.0%), walleye pollock (26.4%), arrowtooth flounder (8.6%), and Pacific cod (3.3%). The 1997 catch also included Tanner crab (5.1%), sculpin (2.2%), and Dungeness crab (0.4%). The continued low abundance of shrimp resources is insufficient to support a commercial fishery.

INTRODUCTION

The commercial trawl shrimp fishery in the Cook Inlet Management Area (H) began with intermittent harvests in the late1950s. By the late 1960s, catches reached five million pounds and remained near that level through the early 1980s (Davis 1982). Shrimp stocks declined drastically in the early 1980s and the commercial fishery has remained closed since the fall of 1986 (Hammarstrom 1991; Table 1). The commercial fishery targeted pandalid shrimp *Pandalus* and *Pandolopsis* species. Pink shrimp *Pandalus borealis* historically comprised the bulk of the commercial harvest, with sidestripe shrimp *Pandalopsis dispar* seasonally contributing a small, but important, portion of the catch. Humpy shrimp *Pandalus goniurus* comprised up to 50% of the annual commercial harvest, but exhibited erratic population fluctuations and contributed little to subsequent fisheries. Coonstripe shrimp *Pandalus hypsinotus* consistently contributed up to 5% of annual harvest. Fishery effort ranged from one vessel during 1968 to 23 vessels in 1981 (Trowbridge, Szarzi, and Bechtol 2000).

Trawl shrimp index surveys have been conducted by the Alaska Department of Fish and Game (ADF&G) to monitor stock status and establish harvest guidelines of shrimp stocks in the Southern District of the Cook Inlet Management Area. Surveys were conducted annually in May during 1971-1975, annually in May and October during 1975–1990, annually in May during 1991-1992, and biennially in May during 1993-1997. Historical surveys focused primarily on shrimp assessment (Gustafson 1994). Beginning in fall 1988, total catch composition was also evaluated in order to document shifts in species composition (Anderson et al. 1997; Bechtol 1997).

Goals of the 1995 and 1997 trawl shrimp surveys were to:

1. Estimate the biomass of Pandalid shrimp in Kachemak Bay.
2. Document the species composition of Pandalid shrimp caught during the surveys.
3. Determine the carapace length frequency and sex ratio of pink shrimp caught during the survey.
4. Estimate the biomass of Pacific cod *Gadus macrocephalus*, walleye pollock *Theragra chalcogramma*, flathead sole *Hippoglossoides elassodon*, and arrowtooth flounder *Atheresthes stomias*.

Although other species of shrimp were caught, only the pandalid species are of commercial value. Within this report, "pandalid shrimp" refers only to pink, sidestripe, coonstripe, and humpy shrimps that are harvested in the commercial fishery. Spot shrimp *Pandalus platyceros* were occasionally caught but comprised less than 0.01% of the pandalid shrimp catch. The term "other shrimp" refers to non-commercial shrimp such as *Lebbeus*, *Crangon*, *Sclerocrangon*, and *Eualus* species.

METHODS

Study Area and Survey Design

The Southern District is largely composed of Kachemak Bay, an embayment of Cook Inlet along the northern Gulf of Alaska (Figure 1). Habitat in this district is typified by mud or sand with occasional hard bottoms, particularly shale or coal. Depths are typically shallower than 35 fathom (64 m), although some areas exceed 90 fathom (165 m). This area is subject to high current flows and tidal fluctuations to 25 feet (46 m). Oceanic currents largely flow counterclockwise in the district and Kachemak Bay waters frequently contain glacial silt.

The survey design delineated Kachemak Bay into a grid of 1.0-nautical mile (nmi) squares (3.4-km^2). Survey stations were selected from the pool of potential stations with water depth greater than 20 fathom (36.6 m). During 1971-1974, selected stations were sampled by single 1.0-nmi tows of a 66-foot Nordby net. Beginning in 1975, the net was changed to a 61-foot headrope, high-rise shrimp net designed by the National Marine Fisheries Service (NMFS). The net style was changed because comparative tows showed the 66-foot Nordby trawl net was only 50% as efficient as the NMFS net (Davis 1982). The NMFS net was subsequently adopted as a standard for shrimp trawl research by NMFS, ADF&G, and Canadian researches in British Columbia (Watson and Bernard 1986; Watson 1987).

The study design has remained relatively consistent throughout the survey time series except for station selection. Stations were originally selected at random from the pool of potential stations. Beginning in spring 1984, the survey design was changed from random to an index estimator with the same stations sampled in an effort to reduce net damage. In 1988, additional stations east of the Homer Spit were added to allay industry concerns that the survey did not adequately sample shrimp concentration areas. These additions increased the total area sampled by 2 square nautical miles. Exploratory tows have also been added in Tutka Bay and Sadie Cove, although these tows were not used in the historical or current biomass estimates.

A stratified index estimator (Cochran 1977) was used to estimate shrimp and fish biomass beginning in 1994. Kachemak Bay was divided into four strata: Far West, Near West, East Open, and East Closed (Figure 1; Gustafson 1994). Stratification was based on habitat type, geographic location, and observed shrimp sex and size. The Far West stratum historically contained few shrimp. The Near West stratum catch contained relatively sparse densities predominately of large female shrimp. The East Open stratum contained moderate densities of both shrimp sexes. The East Closed stratum, which was historically closed to trawl fishing, appeared to be a nursery area mostly containing male shrimp. Index stations in the East Closed, East Open, and Near West strata were sampled with 1.0-nmi tows, whereas 0.5-nmi tows were made in the Far West stratum to reduce potential net damage and complete the survey in a timely manner. Location and depth of trawl tows was similar in the 1995 and 1997 surveys (Appendices A and B: Figures 1 and 2).

Vessel, Gear, and Trawling Procedures

The state research vessel *Pandalus* conducted the trawl shrimp surveys during 22-31 May 1995 and 27 May 27-2 June 1997. The *Pandalus* has an overall length of 66 feet (20.2 m), a 100-ton displacement, and is powered by a 365-hp diesel engine. The vessel fished the high-rise shrimp trawl with 5.5-feet x 8.5-feet, 800-lb, Astoria V-doors attached by triple 10-fathom, 3/8-inch diameter wire bridles (dandy lines). The dandy lines attached to the net headrope with a 24-inch extension chain, to the mid-rib with an 18-inch extension chain, and to the footrope by hammerlocks. The net had 55 feet of 3/8-inch tickler chain attached to the footrope wing tips and suspended under the footrope center by a 4 foot piece of 5/16-inch dropper chain. Sixty-one feet of 3/8-inch height regulating chain connects to the wing tips and is suspended 12 inches under the footrope by six 5/16-inch dropper chains. The whole net, wing, intermediate, and cod end is built with 1.25-inch stretch mesh nylon and the cod end also covered with polypropylene chafing mesh. Twenty-nine 8-inch plastic floats were attached to the head rope for flotation. Estimated fishing width is 32 feet and height is 11.5 feet (Watson 1987). Tows were made for 1 nmi and at a speed of 2.0-2.2 nmi/hr (kts) on a path into the tide. Trawl warp lengths were set at a 3:1 ratio with depth.

In 1995, bottom temperature was recorded approximately once daily with a time-specific temperature logger attached to the trawl headrope. This temperature logger was typically attached on a tow where the likelihood of gear loss or a bottom hang-up was thought to be minor.

Catch Sampling

Upon completion of each successful tow, the total catch was weighed and all large non-shrimp objects as rocks, stumps, and crab pots, were removed from the catch, weighed, and discarded. All Pacific halibut *Hippoglossus stenolepis*, target groundfish, and target invertebrates were removed, counted, and weighed in aggregate by species. Target groundfish included Pacific cod, walleye pollock, sablefish *Anoplopoma fimbria*, skate Family Rajidae, giant wrymouth *Delolepis gigantea*, and rockfish species *Sebastes* species; target invertebrates included Tanner crab *Chionoecetes bairdi*, red king crab *Paralithodes camtschatica*, Dungeness crab *Cancer magister*, weathervane scallop *Patinopecten caurinus*, and octopus *Octopus dofleini*. Pacific cod, walleye pollock, sablefish, and rockfish species were further sampled for individual weight, length, sex, maturity, and age. These size, sex, maturity, and age data will be described in separate reports (Bechtol 1995, 1998). The remaining catch was either sorted in its entirety or a random subsample of 1-3 bushel baskets, weighing approximately 50 lb (23 kg each), was sorted into species or taxonomic groups. Abundance and aggregate weight was determined for each non-shrimp species or taxonomic group from the subsample. Shrimp separated from the bushel samples were either sorted, weighed, and counted by species or weighed in aggregate and further subsampled. This involved sorting a 2.5-kg subsample by shrimp species. Each species was weighed separately for species composition. In addition, up to 400 g of each shrimp species from the subsample were labeled and retained for later length frequency analysis in the laboratory.

During the 1997 survey, an increased number of biological staff allowed the entire catch to be sorted, enumerated, and weighed by species or taxonomic group for 20 tows in which net catch exceeded 150 lb (68 kg).

Laboratory Analysis

In the laboratory, shrimp were measured for carapace length (Butler1980). Pink shrimp were further assessed as male, transitional, female, or ovigerous female sex type based on characteristics of the first and second pleopods (Butler 1980). Size data were pooled within species and also within sex category for pink shrimp.

Data Analysis

Mean catch rates of shrimp or fish species (lb/nmi) was estimated by:

$$\bar{x} = \frac{\sum_{j=1}^{n} \frac{x_j}{d_j}}{n} \quad , \tag{1}$$

where n was the number of tows sampled, x_j is the catch of tow j and d_j is the distance sampled.

Stratification of the historic population data reduced the percent error in the shrimp estimates. However, stratification did not improve statistical precision of the fish estimates. Therefore both stratified and unstratified biomass index estimates are presented in this report.

Biomass (P) for the unstratified sample design was estimated by:

$$\hat{P} = A \ \frac{6076}{32} \ \bar{x} \quad , \tag{2}$$

where the total area (A) in the study was 88 nmi^2 from 1977 through spring 1988 and 90 nmi^2 from fall 1988 through spring 1997, 6,076 was the length of a nautical mile in feet, and 32 is the effective net width in feet.

The variance of the biomass estimate for the unstratified design $(V(\hat{P}))$ was estimated by,

$$V(\hat{P}) = \left(\frac{6076}{32}\right)^2 s^2 \quad , \tag{3}$$

where,

$$s^2 = \frac{\sum_{j=1}^{n}\left(x_j - \bar{x}\right)^2}{n-1} \quad .$$

Ninety-five percent confidence bounds for the unstratified biomass estimate were calculated as:

$$\hat{P} \pm t_{(1-\alpha/2,n-1)}SE \quad ,$$

where *SE* (standard error) is the square root of the sample variance.

Biomass (P_s) for the stratified sample design was estimated by:

$$\hat{P}_S = \left(6076/32\right)\sum_{i=1}^{4} A_i \frac{\sum_{j=1}^{n_i}\frac{x_{ij}}{d_{ij}}}{n_i} \quad , \qquad (4)$$

where A_i is the area of stratum i in nmi^2, and x_{ij} is the catch (lb) and d_{ij} is the tow distance (nmi) of the j^{th} tow in stratum i.

The variance of the biomass estimate for the stratified design ($V\left(\hat{P}_S\right)$) was estimated by,

$$V(\hat{P}_S) = \left(\frac{6076}{32}\right)^2 \sum_{i=1}^{4} A_i^2 \frac{s_i^2}{n_i} \quad , \qquad (5)$$

where,

$$s_i^2 = \sum_{j=1}^{n_i}\frac{\left(x_{ij} - \bar{x}\right)^2}{n_i - 1} \quad .$$

Ninety-five percent confidence bounds for the stratified biomass estimate were approximated by,

$$\hat{P} \pm t_{(1-\alpha/2,n-4)}SE \quad ,$$

where *SE* (standard error) is the square root of the variance.

Relative precision (RP) of the 95% confidence bounds was calculated for all estimates using,

$$RP = \frac{Upper\ bound - Lower\ bound}{\hat{P}} \quad . \qquad (6)$$

RESULTS

1995 Survey

Shrimp

A total of 31 tows was completed during the May 1995 survey, including two tows in Tutka Bay and Sadie Cove (Figure 1, Appendix A). Mean pandalid shrimp catch was 41.2 lb/nmi for the 29 index stations used in the population estimate (Table 2). The unstratified population estimate was 704,115 ±241,479 lb (*SE*=117,910; *RP*=0.34) and the stratified population estimate was 443,368 ±145,593 lb (*SE*=71,090; *RP*=0.33; Table 3).

East Open stratum had the greatest mean catch of pandalid shrimp (49.5 lb/nmi), followed by the Near West stratum (49.2 lb/nmi). Mean catch was 37.1 lb/nmi in the East Closed stratum and 8.5 lb/nmi in the Far West stratum (Table 4). Station P-23 in the East Open stratum had the survey's largest single station pandalid shrimp catch of 148.7 lb/nmi (Table 2; Figure 3). Near West station J-13 had the second largest pandalid shrimp catch of 130.9 lb/nmi.

Shrimp Composition

Shrimp comprised 3.9% of the catch among stations. Species composition included 92.5% pink shrimp, 3.2% sidestripe shrimp, 3.0% other shrimp, 0.9%, coonstripe shrimp, and 0.4% humpy shrimp (Table 2). Species composition within strata was:

Far West	97.7% pink shrimp, 1.2% sidestripe shrimp, 1.2% other shrimp
Near West	88.9 % pink shrimp, 7.7% sidestripe shrimp, 3.4% other shrimp
East Open	96.7% pink shrimp, 1.9% other shrimp, 0.8 % coonstripe shrimp, 0.6% humpy shrimp
East Closed	90.9% pink shrimp, 4.8 % other shrimp, 3.1% coonstripe shrimp, 0.9% humpy shrimp, 0.3% sidestripe shrimp
Tutka / Sadie	94.6% pink shrimp, 3.3% other shrimp, 2.1% coonstripe shrimp.

Pink Shrimp Sex and Length

Pink shrimp sex composition within the Far West stratum included 64% males, 19.8% transitionals, 15.1% females, and 1.2% ovigerous females (Figure 4). Mean carapace lengths were 12.5 mm for males, 15.5 mm for transitionals, 18.6 mm for females, and 16.3 mm for ovigerous females. The Near West stratum yielded 32.8% males, 41.9% transitionals, 24.8% females, and 0.6% ovigerous females with mean carapace lengths of 12.5 mm for males, 16.1 mm for transitionals, 18.7 mm for females, and 17.2 mm for ovigerous females. The East Open stratum yielded 23.1% males, 49.7% transitionals, 30.6% females, and 0.9% ovigerous females, with mean carapace lengths of 12.2 mm for males, 17.2 mm for transitionals, 19.0 mm for females, and 17.2 mm for ovigerous females.

Pink shrimp in the East Closed stratum were comprised of 8.1% males 31.5% transitionals, 19.1% females, and 0.1% ovigerous females with mean carapace lengths of 12.3 mm for males, 17.1 mm for transitionals, 18.7 mm for females, and 17.1 mm for ovigerous females.

Combined Fish and Non-Pandalid Invertebrates

Fish and non-pandalid invertebrates comprised 82.3% of the aggregate 1995 survey catch among stations. Catch rates exceeded 1,000 lb/nmi at six stations. The largest catch was 1,871.1 lb/nmi at station H-14, followed by 1,620.0 lb at Q-24 (Table 5; Figure 5). Mean catch among index stations was 826.5 lb/nmi (Table 6). The unstratified biomass estimate was 14,124,147 ±2,372,743 lb (*SE*= 1,158,566; *RP*=0.17) and the stratified estimate was 12,871,500 ±4,78,607 lb (*SE*= 2,338,675; *RP*=0.37; Table 6). The most abundant groundfish species included walleye pollock (33.4% of total), flathead sole (22.7% of total), arrowtooth flounder (4.3% of total), and Pacific cod (2.3% of total; Appendices C-H). Invertebrate species catches of interest included pandalid shrimp (3.8% of total), Tanner crab (2.4% of total), and Dungeness crab (0.6% of total). The largest Tanner crab catch rate was 169.4 lb/nmi at station K-16 and the largest Dungeness crab catch rate was 82.8 lb/nmi at station N-20 (Figure 1).

Walleye Pollock

Walleye pollock catch rates in 1995 ranged from 52.2 to 1,455.8 lb/nmi with a mean of 349.3 lb/nmi (Table 5; Figure 6). The unstratified population biomass estimate was 5,968,856 ±1,990,109 lb (*SE*= 971,733; *RP*=0.33). The stratified biomass estimate was 5,710,467 ±2,932,125 (*SE*= 1,431,702; *RP*=0.51). Greatest densities were found east of the Homer Spit in the East Closed and East Open strata (Figure 6).

Flathead Sole

Flathead sole catches ranged from 19.2 to 698.8 lb/nmi (Table 5; Figure 7). Mean flathead sole catch rate was 217.3 lb/nmi. The unstratified population biomass estimate was 3,713,630 ±1,251,901 lb (*SE*=611,280; *RP*=0.34) and the stratified estimate was 2,976,522 ±758,253 (*SE*=370,241; *RP*=0.26). The greatest observed catch rate of 689.8 lb/nmi found in Sadie Cove was excluded from the population estimate.

Arrowtooth Flounder

Arrowtooth flounder catch rates ranged from 0.0 to 169.4 lb/nmi (Table 5; Figure 8). Mean catch rate was 47.6 lb/nmi. The unstratified biomass estimate was 814,132 ±327,088 lb (*SE*=159,711; *RP*=0.40) and the stratified estimate was 909,930 ±328,932 (*SE*=160,611; *RP*=0.36). The greatest catch rate was 169.4 lb/nmi at station K-16 in the Near West stratum.

Pacific Cod

Pacific cod catches ranged from 0.0 to 94.0 lb/nmi (Table 5; Figure 9). Mean Pacific cod catch among stations in 1995 was 25.5 lb/nmi. The unstratified biomass population estimate was

435,999 ±142,186 lb (*SE*=69,427; *RP*= 0.33); the stratified estimate was 345,472 ±109,078 lb (SE= 53,261; RP= 0.32). The greatest observed catch rate of 94.0 lb/nmi occurred at station O-21 in the East Open stratum (Figure 1).

Bottom Temperature

Bottom temperature data were successfully recorded during the 1995 survey for the following stations and mean depths: 4.2°C at 15.0 fathom for station P-21; 3.9°C at 29.0 fathom for P-22; 4.6°C at 39.0 fathom for station N-20; and 4.7°C at 58.0 fathom for station L-16.

1997 Survey

Shrimp

A total of 30 tows, including two tows in Tutka Bay and Sadie Cove, were completed during May and June 1997 (Figure 2). Pandalid catch rates ranged from 0.6 to 93.9 lb/nmi (Table7, Figure 10). Greatest catch rates occurred at stations L-15 (93.9 lb/nmi) and L-16 (35.5 lb/nmi) in the Near West stratum. Mean catch rate within stratum was 29.8 lb/nmi in the Near West stratum, 22.9 lb/nmi in the East Closed stratum, 7.7 lb/nmi in the East Open stratum, and 7.1 lb/nmi in the Far West stratum (Table 7). Mean pandalid shrimp catch rate for the index area was 18.8 lb/nmi. The unstratified population biomass estimate was 321,193 ±141,001 lb (*SE*= 68,714; *RP*= 0.44) and the stratified estimate was 236,151 ±87,350 lb (*SE*=42,568; *RP*=0.37; Table 3).

Shrimp Composition
Shrimp comprised 2.5% of the total catch among stations. The species composition was 85.9% pink shrimp, 5.8% other shrimp, 4.4% coonstripe shrimp, 2.1% humpy shrimp, and 1.7% sidestripe shrimp. Shrimp species composition within strata was:

Far West	93.6% pink shrimp, 6.4% other shrimp
Near West	94.6 % pink shrimp, 3.2% sidestripe shrimp, 2.2% other shrimp
East Open	69.2% pink shrimp, 14.5% other shrimp, 12.6 % coonstripe stripe shrimp, 3.7% humpy shrimp
East Closed	76.6% pink shrimp, 9.2 % coonstripe shrimp, 8.4% other shrimp, 3.1%, 5.8% humpy shrimp
Tutka / Sadie	85.9% pink shrimp, 5.8% other shrimp, 4.4% coonstripe shrimp, 2.2% humpy shrimp, 1.7% sidestripe shrimp.

Pink Shrimp Sex and Length
Pink shrimp sex composition within the Far West stratum in 1997 included 28.2% males, 41.3% transitionals, 29.8% females, and 0.7% ovigerous females (Figure 11). Mean carapace lengths were

12.3 mm for males, 16.5 mm for transitionals, 18.3 mm for females, and 15.8 mm for ovigerous females. In the Near West stratum, sex composition was 49.6% males, 33.9% transitionals, 16.5% females, and <0.1% ovigerous females and mean carapace lengths were 12.1 mm for males, 16.5 mm for transitionals, 18.1 mm for females, and 17.0 mm for ovigerous females. Sex composition in the East Open stratum was comprised of 21.8% males, 41.2% transitionals, and 37.8% females, with no ovigerous females. Mean carapace lengths in the East Open stratum were 12.2 mm for males, 16.2 mm for transitionals, and 18.4 mm for females. In the East Closed stratum, sex composition was 23.1% males, 46.6% transitionals, 30.3% females, and no ovigerous females with mean carapace lengths being 12.0 mm for males, 16.2 mm for transitionals, and 18.2 mm for females.

Combined Fish and Non-Pandalid Invertebrates

Mean fish and non-pandalid invertebrate catch rates among index stations in 1997 was 515.3 lb/nmi (Table 8; Figure 12). Maximum observed catches were 1,292.3 lb/nmi at station P-22 in the East Open stratum and 1,064.9 lb/nmi at station K-15 in the Near West stratum. The unstratified biomass estimate was 8,806,016 ±1,677,957 lb (*SE*= 817,718; *RP*=0.19; Table 6) and the stratified estimate was 7,544,935 ±3,463,231 lb (*SE*= 1,687,735; *RP*= 0.46; Table 6). Groundfish species yielding the greatest population estimates were flathead sole (28.0% of total), walleye pollock (26.4% of total), arrowtooth flounder (6.6% of total), Tanner crab (5.1% of total), and Pacific cod (3.3% of total; Appendices I to N)

Flathead Sole

Catch rates of flathead sole ranged from 39.5 to 424.8 lb/nmi (Table 8, Figure 13) and mean catch rate among stations was 166.1 lb/nmi. The greatest observed catch rate of 424.8 lb/nmi from Sadie Cove, with mean catch rates of 211.9 lb/nmi in the Near West stratum and 181.7 lb/nmi in the East Open stratum. The unstratified population biomass estimate was 2,838,283 ±774,817 lb (*SE*=377,591; *RP*=0.27) and the stratified estimate was 2,285,876 ± 990,681 (*SE*=2,285,876; *RP*=0.43).

Walleye Pollock

Walleye pollock catch rates ranged from 24.7 to 509.0 lb/nmi (Table 8, Figure 14). Mean catch rate among index stations was 161.7 lb/nmi, with the greatest station catches in the East Open stratum, which averaged 257.5 lb/nmi. The unstratified population biomass estimate was 2,763,879 ±714,579 lb (*SE*= 348,236; *RP*= 0.26) and the stratified estimate was 1,895,803 ±268,406 lb (*SE*= 138,802; *RP*=0.14).

Arrowtooth Flounder

Arrowtooth flounder catch rates in 1997 ranged from 0.0 to 244.0 lb/nmi (Table 8, Figure 15). Mean catch among index stations was 56.1 lb/nmi, with the greatest observed mean catch rates within strata being 130.5 lb/nmi in the Far West stratum. The unstratified population biomass

estimate was 958,215 ±365,649 lb (*SE*= 178,191; *RP*=0.38) and the stratified biomass estimate was 1,566,955 ±1,067,425 lb (*SE*=520,188, *RP*= 0.68).

Pacific Cod

Pacific cod catch rates ranged from 0.0 to 102.0 lb/nmi (Table 8, Figure 16). Mean catch for all index stations was 22.4 lb/nmi. The greatest catch rate was 102.0 lb/nmi at station K-15 in the Near West stratum (Figure 2). The unstratified population biomass estimate was 382,056 ±132,315 lb (*SE*= 64,481; *RP*=0.35) and the stratified estimate was 391,227 ±224,135 lb (*SE*= 109,227; *RP*=0.57).

DISCUSSION

Pandalid shrimp population abundance in Kachemak Bay still remains insufficient to support a commercial fishery. Although the stratified shrimp biomass index increased four fold between the 1993 and 1995 surveys, the 1995 biomass index of 443,000 lb was the fourth lowest estimate since 1977 (Table 3). The 1997 pandalid index biomass was 236,000 lb, a 47% decline from 1995. In the history of the trawl shrimp survey, only four surveys, the most recent surveys that all occurred within the 1990s, have yielded population index estimates less than 500,000 lb. Pink shrimp were the dominant shrimp species in the 1995 survey, comprising 3.6% of the total survey catch and being the fifth most abundant species (Table 2). In the 1997 survey, pink shrimp declined to 2.6% of the total catch and were the sixth most abundant species (Table 7).

The biomass index estimate for fish and non-pandalid invertebrates in 1995 was the largest observed in the history of Kachemak Bay spring trawl shrimp surveys (Table 6). The three species ranked highest in population biomass contribution during the 1995 survey were walleye pollock (5,969,000 lb), flathead sole (2,977,000 lb), arrowtooth flounder (910,00 lb). By the 1997 survey, the fish and non-shrimp invertebrate biomass had declined 43%. There was also a shift in species composition ranking as the three species ranked highest in population biomass contribution were flathead sole (2,838,000 lb), walleye pollock (1,896,000 lb), and arrowtooth flounder (958,215 lb.

The downward trend in shrimp populations and increase in fish populations in Kachemak Bay is well documented (Figure 17; Bechtol 1997). This ecological regime shift has been identified as occurring across the northern Gulf of Alaska and is believed related to Pacific Decadal Oscillation (PDO), a cyclic climatic event that affects ocean temperature (Anderson et al.1997). Fish population biomass, primarily gadids such as walleye pollock and Pacific cod, and also flathead sole, exceeded shrimp biomass in 1986, increased to the largest index biomass in 1995, then declined in 1997. The 1998 Kodiak district shrimp surveys have shown similar trends with fish exceeding shrimp catches since 1978 (Ruccio 1999). Gulf of Alaska and Bering Sea food habit studies found shrimp to be a major diet component for large walleye pollock, Pacific cod, arrowtooth flounder, and rockfish species (Yang 1993, Worton and Urban 1999, Zgurovsky et al.

1990). Therefore, the decline in shrimp biomass index between 1995 and 1997 was not unexpected with increases in recent years of the large predator population of walleye pollock and flathead sole.

In addition to predation, oceanographic changes have been correlated to declines in shrimp abundance. The PDO resulted in a gradual warming of air, surface, and sub-surface water temperature in the North Pacific Ocean. This warming has been correlated to the shift from pandalid shrimp and crab to fish (Loy 1999). Laboratory studies have also shown that pink shrimp have narrow thermal requirements for reproduction, egg survival, and larval survival. Optimal temperatures are 3°C to 6°C; a high incidence of female sterility occurs at temperatures greater than 9°C and shrimp larval survival is significantly reduced at temperatures of 9°C to 11°C (Nunes 1984). Although benthic water temperatures in Kachemak Bay during the 1995 survey were within the optimum range for pink shrimp as determined by Nunes (1984), the Kachemak Bay ecosystem is a balance of predator and prey populations within the set of underlying environmental conditions.

Rebuilding of shrimp stocks to levels that will support commercial harvests will require substantial reductions in the predatory fish populations and will likely depend upon changes in oceanographic conditions. Increases in shrimp populations will then depend upon increases in appropriate forage base and complimentary predator species to facilitate increases in shrimp productivity. The next survey of pandalid shrimp in Kachemak Bay is scheduled to occur in May 2000.

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Table 1. Harvest history in the Kachemak Bay trawl shrimp fishery, Cook Inlet Management Area, 1969-1998.

Season[a/]	Vessels	June1 to Oct.31	Nov. 1 to Mar. 31	April 1 to May 31	Total
1969-70	7	1,289,656	1,692,854	889,330	3,871,840
1970-71	3	3,211,924	2,076,228	617,836	5,905,988
1971-72	7	2,618,630	1,761,569	140,707	4,520,906
1972-73	10	2,772,422	2,109,660		4,882,082
1973-74	13	2,502,154	2,323,780		4,825,934
1974-75	4	2,512,764	2,519,148		5,031,912
1975-76	4	1,997,563	2,421,456		4,419,019
1976-77	5	2,545,885	2,453,101		4,998,986
1977-78	7	2,490,969	2,546,977		5,037,946
1978-79	6	2,952,733	3,060,066		6,012,799
		July 1 to Sept. 30	Oct.1 to Dec.31	Jan. 1 to Mar. 31	
1979-80	7	2,013,298	2,052,646	1,731,483	5,797,427
1980-81	15	1,780,298	2,691,746	1,704,706	6,176,750
1981-82	23	1,614,868	1,686,781	1,693,850	4,995,499
1982-83	15	998,522	1,012,388	1,009,857	3,020,767
1983-84	10	Closed	Closed	525,508	525,508
1984-85	10	519,651	528,506	518,529	1,566,686
1985-86	2	488,606	257,782	503,340	1,249,728
1986-87	3	504,206	Closed	Closed	504,206
1987-88	0	Closed	Closed	Closed	
1988-89	0	Closed	Closed	Closed	
1989-90	0	Closed	Closed	Closed	
1990-91	0	Closed	Closed	Closed	
1991-92	0	Closed	Closed	Closed	
1992-93	0	Closed	Closed	Closed	
1993-94	0	Closed	Closed	Closed	
1994-95	0	Closed	Closed	Closed	
1995-96	0	Closed	Closed	Closed	
1996-97	0	Closed	Closed	Closed	
1997-98		Closed by the Alaska Board of Fisheries			

a/ Regulatory management seasons, with corresponding guidelines, established in 1973.

Table 2. Shrimp catch from the Kachemak Bay index trawl survey, 1995.

Station	Shrimp Species					Total Commercial Pandalid	Other Shrimp Species
	Pink	Humpy	Coonstripe	Sidestripe	Spot		
	lb/nmi						
Far West							
H-11	15.0	0.0	0.0	0.2	0.1	15.3	0.1
J-11	0.2	0.0	0.0	0.0	0.0	0.2	0.0
H-12	15.0	0.0	0.0	0.2	0.1	15.3	0.1
I-12	3.3	0.0	0.0	0.0	0.0	3.3	0.2
Near West							
J-13	130.7	0.0	0.0	0.2	0.0	130.9	0.0
K-13	2.7	0.0	0.0	0.0	0.0	2.7	0.4
H-14	11.1	0.0	0.0	0.0	0.0	11.1	0.3
K-14	65.0	0.0	0.0	5.1	0.0	70.1	0.3
I-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K-15	38.1	0.0	0.0	12.4	0.0	50.5	0.6
L-15	32.6	0.0	0.0	1.9	0.0	34.5	0.2
K-16	85.1	0.0	0.0	11.4	0.0	96.5	4.7
L-16	65.2	0.0	0.0	7.0	0.0	72.2	9.4
L-17	22.6	0.0	0.0	1.3	0.0	23.9	1.3
East Closed							
Q-24	12.7	1.2	1.4	0.0	0.0	15.3	0.5
R-24	13.3	0.5	0.9	0.0	0.0	14.7	0.7
R-25	44.3	0.0	0.1	0.0	0.0	44.4	0.1
S-25	24.7	0.1	0.8	0.0	0.0	25.6	7.0
T-26	39.2	0.2	1.7	0.4	0.0	41.5	0.6
U-27	78.4	0.0	2.4	0.2	0.0	81.0	2.4
East Open							
N-20	42.7	0.0	0.0	0.0	0.1	42.8	1.0
N-21	59.3	0.0	0.0	0.0	0.0	59.3	0.5
O-21	42.6	0.1	0.1	0.0	0.6	43.4	1.5
P-21	0.8	0.6	1.5	0.0	0.0	2.9	1.0
O-22	50.3	0.1	0.0	0.0	0.0	50.4	0.2
N-22	16.7	0.0	0.0	0.0	0.0	16.7	0.0
P-22	17.2	0.2	1.8	0.0	0.0	19.2	1.8
P-23	147.2	1.5	0.0	0.0	0.0	148.7	0.0
O-23	61.8	0.4	0.2	0.1	0.0	62.5	2.4
Tutka & Sadie							
H-18	31.6	0.0	0.8	0.0	0.0	32.4	1.3
C\D-20	5.2	0.0	0.0	0.0	0.0	5.2	0.0
Total	1,174.6	4.9	11.7	40.4	0.9	1,232.5	38.6
% of all Shrimp	92.5%	0.4%	0.9%	3.2%	<0.1%	97.0%	3.0%
% of all Catch	3.6%	0.0%	0.0%	0.1%	<0.1%	3.8%	0.1%

Table 3. Unstratified and stratified index estimates for the Kachemak Bay pandalid shrimp population, 1977-1997.

Year	Mean Catch (lb/nmi)	No of Stations	Unstratified Estimate (million lb)	Unstratified Relative Precision	Stratified Estimate (million lb)	Stratified Relative Precision	Commercial Harvest (lb)
Spring Surveys							
1977	407.9	40	6.82	0.26	6.45	0.22	5,037,946
1978	810.9	36	13.55	0.38	13.36	0.36	6,012,799
1979	743.9	41	12.43	0.31	12.26	0.33	5,797,427
1980	500.9	40	8.37	0.26	8.06	0.28	6,177,129
1981	486.1	37	8.12	0.27	7.17	0.23	4,995,499
1982	306.7	38	5.13	0.32	4.50	0.27	3,020,767
1983	204.0	37	3.41	0.37	3.28	0.23	525,508
1984	282.3	34	4.72	0.51	4.26	0.21	1,566,686
1985	221.7	34	3.70	0.59	3.49	0.23	1,249,728
1986	157.2	34	2.63	0.76	2.47	0.57	504,206
1987	178.9	34	2.99	0.67	2.69	0.25	0
1988	247.5	33	4.14	0.67	3.67	0.23	0
1989	119.5	39	2.04	0.90	1.73	0.66	0
1990	220.9	41	3.77	1.12	3.27	1.07	0
1991	83.0	41	1.42	0.55	1.11	0.44	0
1992	72.9	36	1.25	0.34	0.90	0.31	0
1993	10.4	35	0.18	0.41	0.12	0.39	0
1995	41.2	29	0.70	0.34	0.44	0.33	0
1997	18.8	28	0.32	0.44	0.24	0.37	0
Fall Surveys							
1977	738.4	36	12.34	0.43	10.67	0.38	5,037,946
1978	1,160.3	32	19.39	0.38	17.20	0.42	6,012,799
1979	1,133.3	32	18.94	0.35	18.33	0.36	5,797,427
1980	1,689.4	37	28.23	0.29	27.19	0.32	6,177,129
1981	604.8	35	10.11	0.40	9.71	0.44	4,995,499
1982	519.2	36	8.68	0.39	8.22	0.27	3,020,767
1983	481.3	36	8.04	0.54	7.82	0.17	525,508
1984	532.0	35	8.89	0.39	7.47	0.21	1,566,686
1985	284.9	34	4.76	0.47	4.18	0.17	1,249,728
1986	153.6	34	2.57	0.56	2.35	0.27	504,206
1987	227.0	34	3.79	0.98	3.52	0.74	0
1988	161.9	35	2.77	0.76	2.05	0.49	0
1989	131.9	40	2.24	0.49	1.62	0.26	0
1990	104.5	42	1.78	0.67	1.50	0.37	0
Fall survey discontinued in 1991							

Table 4. Mean catch of pandalid shrimp in the Kachemak Bay trawl index survey, 1977-1997.

Year	East Closed	East Open	Near West	Far West
	Spring Survey (lb/nmi)			
1977	585.2	772.2	495.7	214.4
1978	541.0	1,420.5	621.2	801.8
1979	474.0	718.1	858.0	744.1
1980	283.7	648.7	586.0	458.3
1981	572.3	590.8	836.5	207.3
1982	230.7	524.8	556.5	118.5
1983	521.3	543.6	195.8	42.4
1984	694.6	1,181.0	127.4	0
1985	786.0	886.0	5.8	0
1986	657.4	502.8	4.5	0
1987	976	150.0	54.5	0
1988	1,334.4	173.0	88.8	0
1989	729.3	22.3	5.5	0.1
1990	1,311.7	103.7	12.9	0.4
1991	337.2	92.5	34.3	1.3
1992	105.6	114.6	73.4	16.5
1993	10.9	17.1	13.4	1.4
1995	37.1	49.5	49.2	8.5
1997	22.9	7.7	29.8	7.1
	Fall Surveys (lb/nmi)			
1977	731.3	961.2	1,595.4	189.4
1978	309.7	863.3	1,895.5	1,425.6
1979	376.9	616.2	1,540.2	1,127.5
1980	996.3	1,824.2	2,027.2	1,594.4
1981	378.3	623.7	759.9	556.1
1982	1,012.0	1,431.8	550.2	143.8
1983	2,101.6	1,322.5	152.9	0
1984	897.4	1,545.8	715.5	5.3
1985	612.8	1,101.5	201.7	0
1986	445.2	636.3	37.6	0
1987	1,403.8	162.3	4.5	0
1988	834.0	63.9	2.3	0
1989	499.0	197.0	6.8	0.5
1990	572.5	78.6	2.5	0.4
	Fall survey discontinued in 1991.			

Table 5. Catch rates of fish and shellfish in the Kachemak Bay trawl index survey, 1995.

Station	Commercial Pandalid Shrimp	Non-Pandalid Shrimp Catch												Debris	Total Catch
		Tanner Crab	Dungeness Crab	Pacific Cod	Walleye Pollock	Flathead Sole	Arrowtooth Flounder	Sculpin Species	Halibut	Skate Species	Starry Flounder	Other Species	Total-Non-Pandalid. Catch		
	lb/nmi														
Far West															
H-11/12	30.6	12.0	0.0	12.0	260.0	366.8	61.2	7.6	16.0	170.0	0.0	223.4	1,129.0	36.2	1,195.8
J-11	0.2	0.5	0.0	22.0	287.0	63.3	84.4	0.4	0.0	0.0	0.0	54.7	512.3	3.1	515.6
I-12	3.3	0.0	0.0	20.0	748.0	123.6	88.3	0.0	0.0	0.0	0.0	39.5	1,019.4	1.0	1,023.7
Near West															
J-13	130.9	3.1	0.0	36.0	246.8	566.7	78.7	2.3	0.0	8.0	0.0	145.5	1,087.1	22.0	1,240.0
K-13	2.7	0.0	0.0	36.0	622.0	93.6	106.0	0.0	0.0	0.0	0.0	11.3	868.9	0.0	871.6
H-14	11.1	2.0	0.0	30.0	517.5	337.1	72.6	245.2	76.0	84.0	0.0	506.7	1,871.1	53.7	1,935.9
K-14	70.1	108.0	0.0	20.0	90.0	367.2	0.0	0.3	0.0	22.0	0.5	56.8	664.8	15.7	750.6
I-14	0.0	1.0	0.0	12.3	0.0	19.2	6.7	46.1	16.0	0.0	0.0	104.4	205.7	0.0	205.7
K-15	50.5	47.0	0.0	30.0	133.8	286.3	134.2	18.5	8.0	45.8	0.0	64.2	767.8	40.1	858.4
L-15	34.5	28.1	0.0	12.0	110.0	170.3	68.1	0.9	0.0	50.0	0.0	6.7	446.1	119.2	599.8
K-16	96.5	169.4	0.0	34.0	74.3	148.2	169.4	7.2	12.0	0.0	0.0	140.0	754.5	18.2	869.2
L-16	72.2	0.0	0.0	30.0	116.7	283.6	150.0	106.3	8.0	0.0	0.0	49.2	743.8	0.0	816.0
L-17	23.9	65.2	0.0	28.0	52.2	195.7	130.0	0.5	8.0	0.0	0.0	19.3	498.9	195.7	718.5

Table 5. Continued.

Station	Commercial Pandalid Shrimp	Non-Pandalid Shrimp Catch												Debris	Total Catch
		Tanner Crab	Dungeness Crab	Pacific Cod	Walleye Pollock	Flathead Sole	Arrowtooth Flounder	Sculpin Species	Halibut	Skate Species	Starry Flounder	Other Species	Total-Non-Pandalid. Catch		
	lb/nmi														
East Closed															
Q-24	15.3	3.3	0.0	26.6	1,455.8	20.4	24.5	23.6	0.0	0.0	24.5	37.9	1,620.0	274.2	1,906.6
R-24	14.7	9.4	12.3	66.0	438.2	70.2	7.4	28.9	19.0	10.0	132.2	54.9	848.0	32.2	896.1
R-25	44.4	0.1	0.0	24.0	585.1	68.6	3.2	22.9	8.0	0.0	45.8	27.4	785.0	2.5	832.1
S-25	25.6	2.1	2.0	60.0	265.0	61.8	6.7	26.5	22.0	0.0	123.6	26.1	596.0	0.0	628.4
T-26	41.5	10.0	8.7	5.0	362.0	68.1	0.0	37.7	192.0	0.0	204.3	46.2	934.0	62.1	1,038.2
U-27	81.0	0.0	0.0	16.0	91.9	102.1	0.0	0.0	61.0	0.0	101.3	444.1	818.0	78.7	978.5
East Open															
N-20	42.8	62.1	82.8	64.0	476.0	787.0	42.2	31.0	0.0	0.0	0.0	41.8	1,587.0	62.1	1,692.7
N-21	59.3	0.0	0.0	0.0	205.3	648.2	52.0	1.6	12.0	0.0	0.0	6.6	926.0	2.6	988.1
O-21	43.4	28.3	7.3	94.0	226.3	425.3	9.9	19.8	0.0	0.0	0.0	33.7	845.0	80.1	969.0
P-21	2.9	0.7	0.0	30.0	71.8	66.7	3.3	60.1	6.7	0.0	16.7	35.0	291.0	10.0	304.9
O-22	50.4	2.4	0.0	0.0	277.4	158.8	9.0	0.0	24.0	0.0	0.0	3.0	475.0	2.7	527.9
N-22	16.7	16.2	0.0	22.0	538.3	97.3	59.4	7.6	0.0	45.0	0.0	2.9	789.0	6.5	811.9
P-22	19.2	166.5	65.3	2.0	401.7	199.9	9.5	99.9	0.0	0.0	0.0	75.3	1,020.0	3,318.9	4,360.0
P-23	148.7	5.2	4.6	8.0	700.1	97.4	0.0	52.0	8.0	0.0	0.0	33.5	909.0	24.4	1,081.9
O-23	62.5	3.7	0.0	0.0	556.8	374.1	4.9	1.6	0.0	0.0	0.0	11.6	953.0	8.4	1,026.0
Tutka Bay and Sadie Cove															
H-18	32.4	0.0	0.0	0.0	529.1	698.8	7.4	276.6	67.0	0.0	0.0	53.4	1,632.0	0.0	1,666.0
C/D-20	5.2	14.6	0.0	0.0	356.1	357.2	0.1	77.0	18.0	0.0	27.6	143.0	993.7	5.1	1,003.9
Total Among All Stations															
Total	1,232.5	760.9	183.0	739.9	10,795.2	7,323.5	1,389.1	1,202.1	581.7	434.8	676.5	2,498.0	26,594.7	4,475.4	32,330.3
Percent	3.8%	2.4%	0.6%	2.3%	33.4%	22.7%	4.3%	3.7%	1.8%	1.3%	2.1%	7.7%	82.3%	13.8%	100.0%

Table 6. Biomass indices for non-shrimp species in the Kachemak Bay trawl survey, 1977-1997.

Year	Mean Catch (lb/nmi)	No of Stations	Unstratified Estimate (million lb)	Relative Precision	Stratified Estimate (million lb)	Relative Precision
			Spring Surveys			
1977	104.5	40	1.75	0.40	1.83	0.14
1978	150.5	36	2.51	0.28	2.63	0.12
1979	157.3	41	2.63	0.26	2.53	0.17
1980	82.9	40	1.38	0.26	1.47	0.18
1981	262.8	37	4.39	0.29	4.28	0.39
1982	no data	38				
1983	132.0	37	2.99	0.31	2.16	0.39
1984	179.1	34	4.91	0.21	3.15	0.16
1985	293.9	34	4.07	0.58	5.38	0.21
1986	243.4	34	3.60	0.59	4.06	0.71
1987	215.2	34	11.03	0.33	3.37	0.38
1988	660.3	33	9.48	0.13	10.83	0.14
1989	554.8	39	8.82	0.35	9.71	0.45
1990	516.1	41	10.98	0.18	7.59	0.20
1991	642.3	41	10.23	0.17	10.60	0.17
1992	598.8	36	9.32	0.20	8.62	0.16
1993	545.7	35	14.19	0.15	8.99	0.18
1995	826.5	29	15.63	0.16	12.87	0.36
1997	515.3	28	8.81	0.18	7.54	0.44
			Fall Surveys			
1977	177.4	36	2.96	0.26	2.69	0.27
1978	471.2	32	7.87	0.35	7.22	0.52
1979	267.3	32	4.48	0.34	4.18	0.41
1980	402.4	37	6.72	0.27	6.27	0.36
1981	507.2	35	8.47	0.29	8.35	0.43
1982	664.4	36	11.10	0.34	9.65	0.51
1983	705.6	36	11.79	0.27	10.74	0.24
1984	475.0	35	7.94	0.35	6.97	0.38
1985	927.8	34	15.50	0.42	17.21	0.11
1986	259.3	34	4.33	0.30	3.93	0.34
1987	1,004.9	34	16.79	0.26	16.25	0.31
1988	1,048.0	35	17.91	0.22	16.07	0.33
1989	1,160.1	40	19.82	0.19	21.46	0.21
1990	1,050.0	42	17.95	0.21	15.55	0.33
			Fall Surveys Discontinued after 1990			

Table 7. Shrimp catch in the Kachemak Bay index trawl survey, 1997.

Station	Pandalid Shrimp Species					Commercial Pandalid	Other Shrimp
	Pink	Humpy	Coonstripe	Sidestripe	Spot		
	lb/nmi						
Far West							
J-11	2.6	0.0	0.0	0.0	0.0	2.6	0.1
H-12	9.9	0.0	0.0	0.0	0.0	9.9	0.0
I-12	8.7	0.0	0.0	0.0	0.0	8.7	1.3
Near West							
J-13	17.2	0.0	0.0	0.3	0.0	17.5	0.1
K-13	26.7	0.0	0.0	0.3	0.0	27.0	0.2
H-14	5.8	0.0	0.0	0.0	0.0	5.8	0.2
K-14	27.7	0.0	0.0	2.1	0.0	29.8	1.3
I-14	7.1	0.0	0.0	0.0	0.0	7.1	0.3
K-15	29.8	0.0	0.0	2.5	0.0	32.3	0.0
L-15	93.9	0.0	0.0	0.0	0.0	93.9	0.6
K-16	23.1	0.0	0.0	3.5	0.0	26.6	0.9
L-16	35.4	0.0	0.1	0.0	0.0	35.5	1.4
L-17	21.8	0.0	0.0	1.1	0.0	22.9	1.8
East Closed							
Q-24	3.8	1.6	1.7	0.0	0.0	7.1	1.4
R-24	4.2	0.1	0.2	0.0	0.0	4.4	0.6
R-25	8.3	0.0	0.2	0.0	0.0	8.5	0.4
S-25	2.4	0.1	0.1	0.0	0.0	2.5	0.2
T-26	49.1	0.5	3.6	0.0	0.0	53.2	2.9
U-27	47.0	6.5	8.1	0.0	0.0	61.6	7.0
East Open							
N-20	0.6	0.0	0.0	0.0	0.0	0.6	0.0
N-21	5.8	0.0	0.0	0.0	0.0	5.8	0.9
O-21	2.9	0.0	0.1	0.0	0.0	3.0	0.0
P-21	3.8	1.3	7.5	0.0	0.0	12.6	4.1
O-22	1.3	0.0	0.0	0.0	0.0	1.4	0.2
N-22	31.6	0.0	0.2	0.0	0.0	31.8	3.4
P-22	4.3	0.9	1.7	0.0	0.0	6.8	2.1
P-23	2.8	0.3	0.3	0.0	0.0	3.4	0.5
O-23	3.1	0.5	0.5	0.0	0.0	4.0	0.7
Tutka & Sadie							
C\D-20	1.7	0.0	0.5	0.0	0.0	2.2	0.1
H-18	2.2	0.0	0.5	0.0	0.0	2.7	0.2
Total (lb/nmi)	484.6	11.8	25.1	9.7	0.0	531.1	32.8
% of all Shrimp	85.9%	2.1%	4.4%	1.7%	0.0%	94.2%	5.8%
% of all Catch	2.6%	0.1%	0.1%	0.1%	0.0%	2.8%	0.2%

Table 8. Catch rates of fish and shellfish in the Kachemak Bay trawl index survey, 1997.

Station	Commercial Pandalid Shrimp	Non-Pandalid Shrimp Catch												Debris	Total Catch
		Tanner Crab	Dungeness Crab	Pacific Cod	Walleye Pollock	Flathead Sole	Arrowtooth Flounder	Sculpin Species	Halibut	Skate Species	Starry Flounder	Other Species	Total-Non-Pandalid. Catch		
	lb/nmi														
Far West															
J-11	2.6	9.4	0.0	1.3	64.6	54.9	71.1	0.0	0.0	0.0	0.0	15.6	216.9	0.8	220.3
H-12	9.9	19.1	0.0	29.7	55.1	48.8	76.3	0.8	0.0	2.1	0.0	54.0	285.9	0.0	295.8
I-12	8.7	7.9	0.0	39.0	70.7	200.0	244.0	1.4	0.0	15.7	0.0	26.8	605.5	0.0	614.2
Near West															
J-13	17.5	2.1	0.0	0.0	28.6	67.4	44.9	0.0	0.0	0.0	0.0	14.7	157.7	0.6	175.8
K-13	27.0	2.1	0.0	4.0	50.6	111.0	62.3	1.7	0.0	0.0	0.0	23.8	255.5	0.9	283.4
H-14	5.8	0.2	0.0	30.0	204.0	342.0	84.0	0.0	24.0	104.0	0.0	19.2	807.4	0.0	813.2
K-14	29.8	6.1	0.0	16.0	54.0	365.9	69.0	2.4	0.0	0.0	0.0	30.4	543.8	2.9	576.4
I-14	7.1	0.6	0.0	0.0	120.0	258.6	38.6	5.9	0.0	0.0	0.0	9.1	432.8	0.0	439.9
K-15	32.3	414.0	0.0	102.0	66.0	223.3	136.9	0.0	0.0	59.9	0.0	62.8	1,064.9	112.4	1,209.6
L-15	93.9	13.0	0.0	16.0	120.0	343.7	57.2	0.1	0.0	20.0	0.0	5.4	575.4	28.6	697.9
K-16	26.6	2.1	14.4	16.4	24.7	182.9	125.4	5.8	0.0	45.2	0.0	63.8	480.7	0.0	507.3
L-16	35.5	125.8	0.0	32.0	146.9	167.0	112.7	1.6	6.0	12.0	0.0	33.6	637.6	44.9	718.0
L-17	22.9	29.3	0.0	31.7	101.4	57.1	76.1	4.7	0.0	0.0	0.0	19.9	320.2	2.7	345.8

Table 8. Continued.

Station	Commercial Pandalid Shrimp	Non-Pandalid Shrimp Catch												Debris	Total Catch
		Tanner Crab	Dungeness Crab	Pacific Cod	Walleye Pollock	Flathead Sole	Arrowtooth Flounder	Sculpin Species	Halibut	Skate Species	Starry Flounder	Other Species	Total-Non-Pandalid. Catch		
	lb/nmi														
East Closed															
Q-24	7.1	0.0	0.0	26.5	113.9	47.9	0.7	0.5	38.0	0.0	15.1	190.0	432.6	45.5	485.2
R-24	4.4	9.7	0.0	31.0	215.5	151.4	5.8	6.0	0.0	0.0	5.8	14.3	439.5	23.3	467.2
R-25	8.5	0.1	0.0	15.7	167.3	69.7	6.9	13.9	0.0	0.0	5.2	6.4	285.2	15.6	309.3
S-25	2.5	0.1	0.0	4.2	185.7	39.5	6.2	2.8	3.4	0.0	0.0	7.7	249.6	3.4	255.5
T-26	53.2	11.2	0.0	22.0	294.5	161.0	44.5	2.8	111.0	24.0	0.0	35.0	706.1	699.5	1,458.8
U-27	61.6	22.4	1.0	25.8	128.0	123.1	0.0	15.3	18.0	64.0	92.0	49.7	539.3	345.8	946.7
East Open															
N-20	0.6	0.0	0.0	11.9	187.4	40.9	8.3	0.0	0.0	0.0	0.0	2.9	251.4	0.0	252.0
N-21	5.8	2.2	4.4	4.3	230.2	269.7	78.9	4.4	4.3	0.0	0.0	6.7	605.1	0.0	610.9
O-21	3.0	1.9	0.0	0.0	150.0	92.8	4.4	3.4	0.0	0.0	0.0	3.6	256.1	20.4	279.5
P-21	12.6	2.6	0.0	25.0	322.0	138.0	27.6	35.6	4.0	26.8	0.0	100.6	682.2	147.4	842.2
O-22	1.4	0.0	0.0	28.0	509.0	72.7	9.7	8.1	0.0	0.0	0.0	0.9	628.4	0.0	629.7
N-22	31.8	31.8	3.0	44.0	156.0	287.3	131.3	2.7	0.0	0.0	0.0	21.5	677.6	61.1	770.5
P-22	6.8	207.7	51.9	12.0	218.0	503.0	6.4	18.1	110.0	0.0	0.0	165.2	1,292.3	696.5	1,995.6
P-23	3.4	0.3	0.0	17.4	354.8	102.2	14.0	36.7	2.6	21.0	0.0	2.6	551.6	10.5	565.5
O-23	4.0	0.0	0.0	40.3	190.4	128.8	26.9	11.5	38.0	0.0	0.0	4.6	440.5	14.7	459.2
Tutka Bay and Sadie Cove															
C\D-20	2.2	44.6	0.0	0.0	208.9	215.8	6.6	172.9	0.0	0.0	1.5	93.2	743.5	65.7	811.4
H-18	2.7	0.9	0.0	0.0	249.8	424.8	53.9	75.9	0.0	0.0	0.0	30.8	836.2	2.7	841.6
Total Among All Stations															
Total	531.1	967.2	74.7	626.2	4,988.0	5,291.1	1,630.5	410.6	329.3	135.8	119.6	1,114.9	16,001.2	2,345.9	18,878.3
Percent	2.8%	5.1%	0.4%	3.3%	26.4%	28.0%	8.6%	2.2%	1.7%	0.7%	0.6%	5.9%	84.8%	12.4%	100.0%

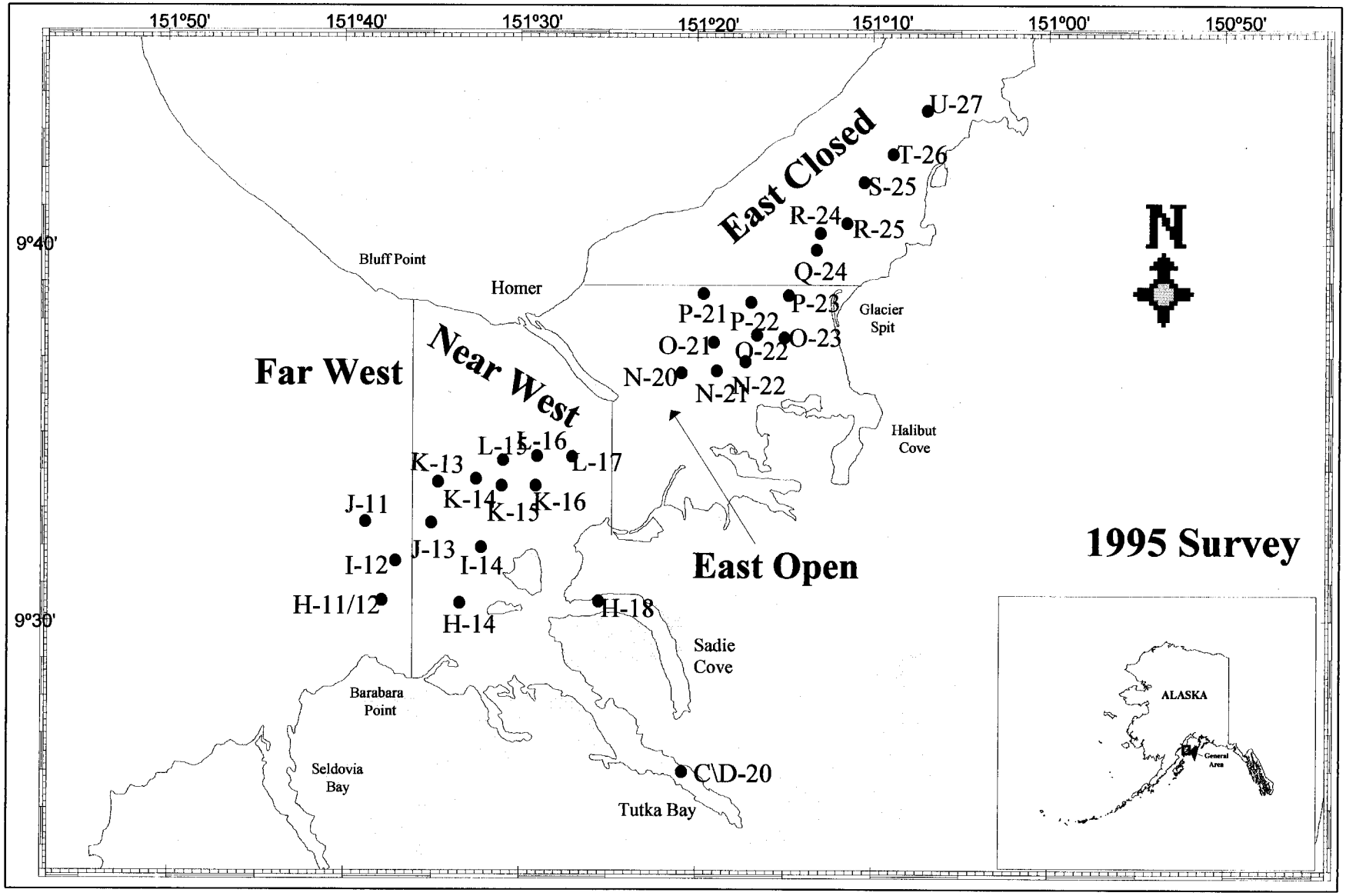

Figure 1. Survey strata and tow midpoints during the Kachemak Bay trawl shrimp survey, 1995.

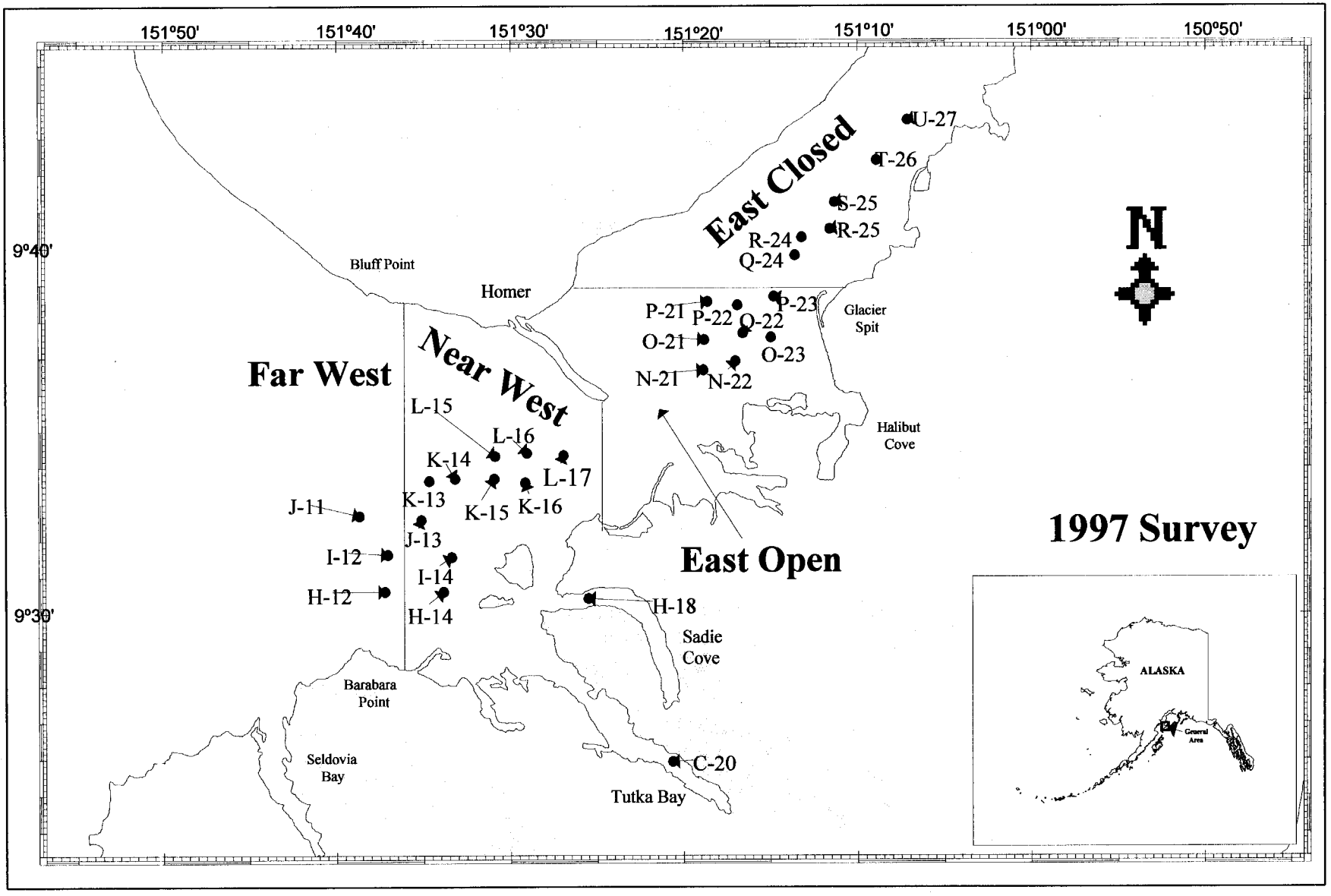

Figure 2. Survey strata and tow midpoints during the Kachemak Bay trawl shrimp survey, 1997.

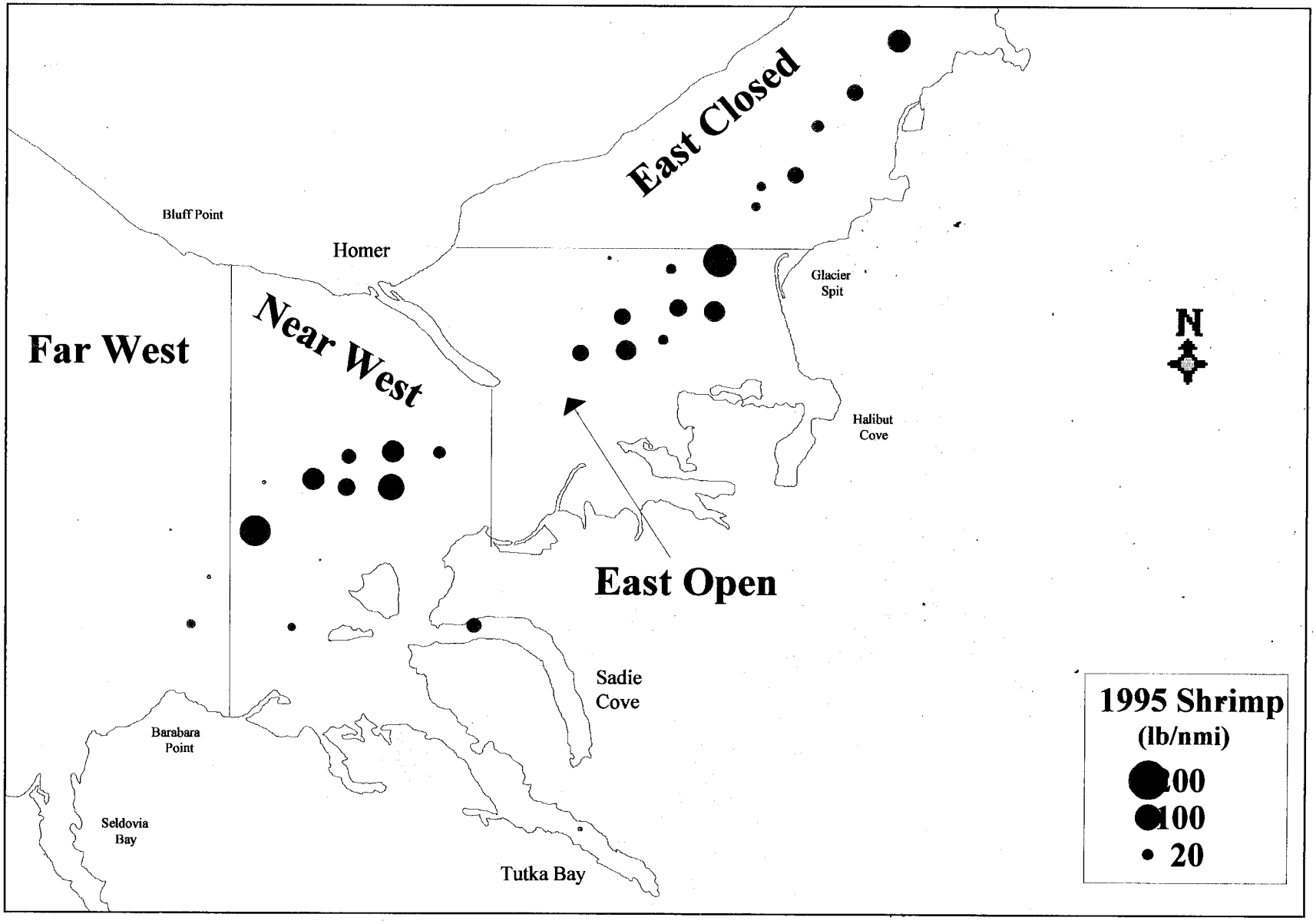

Figure 3. Pandalid shrimp catch rates in the Kachemak Bay trawl survey, 1995

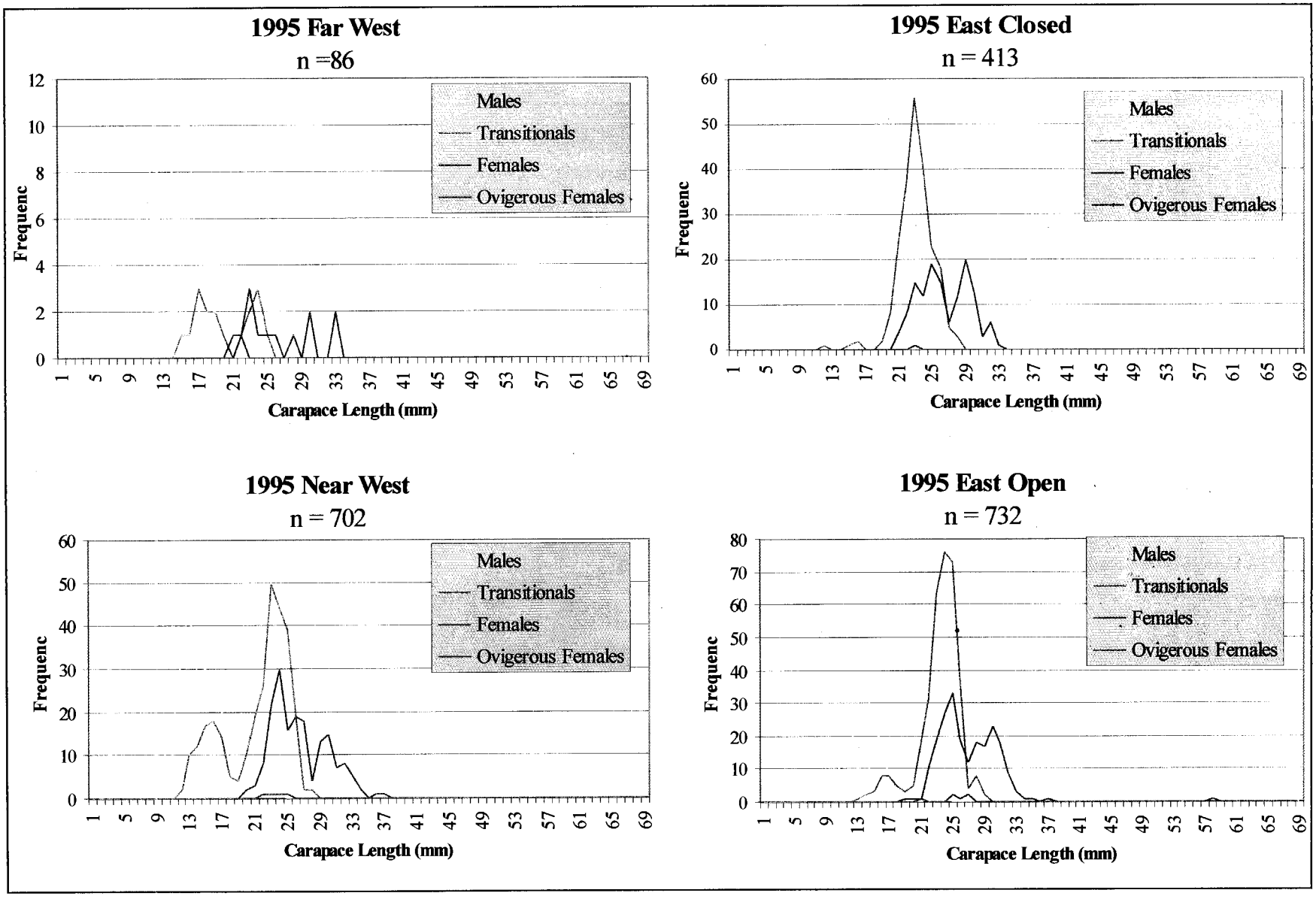

Figure 4. Pink shrimp length frequency by sex and strata in the Kachemak Bay trawl survey, 1995.

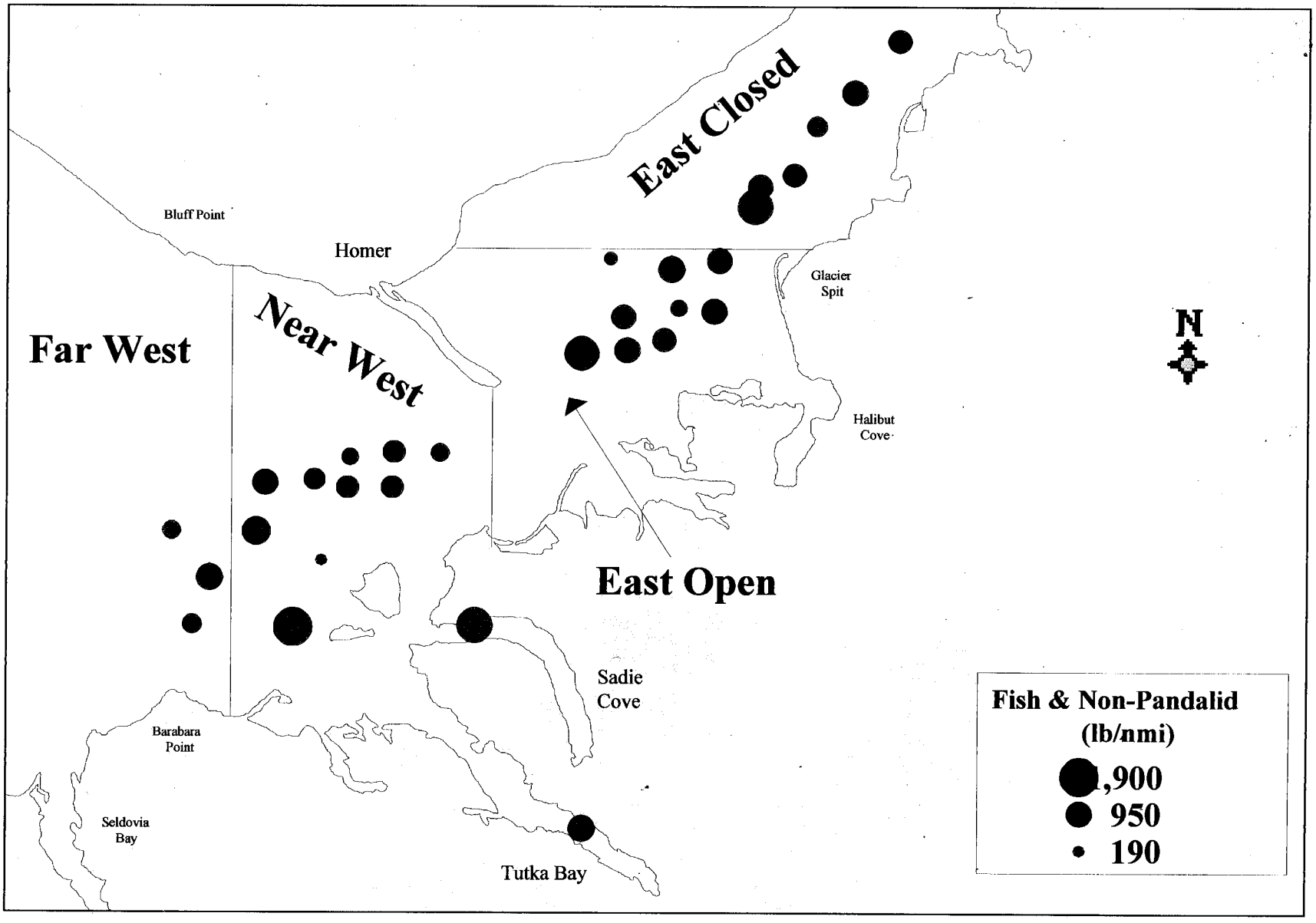

Figure 5. Non-pandalid catch rates by station in the Kachemak Bay trawl shrimp survey, 1995.

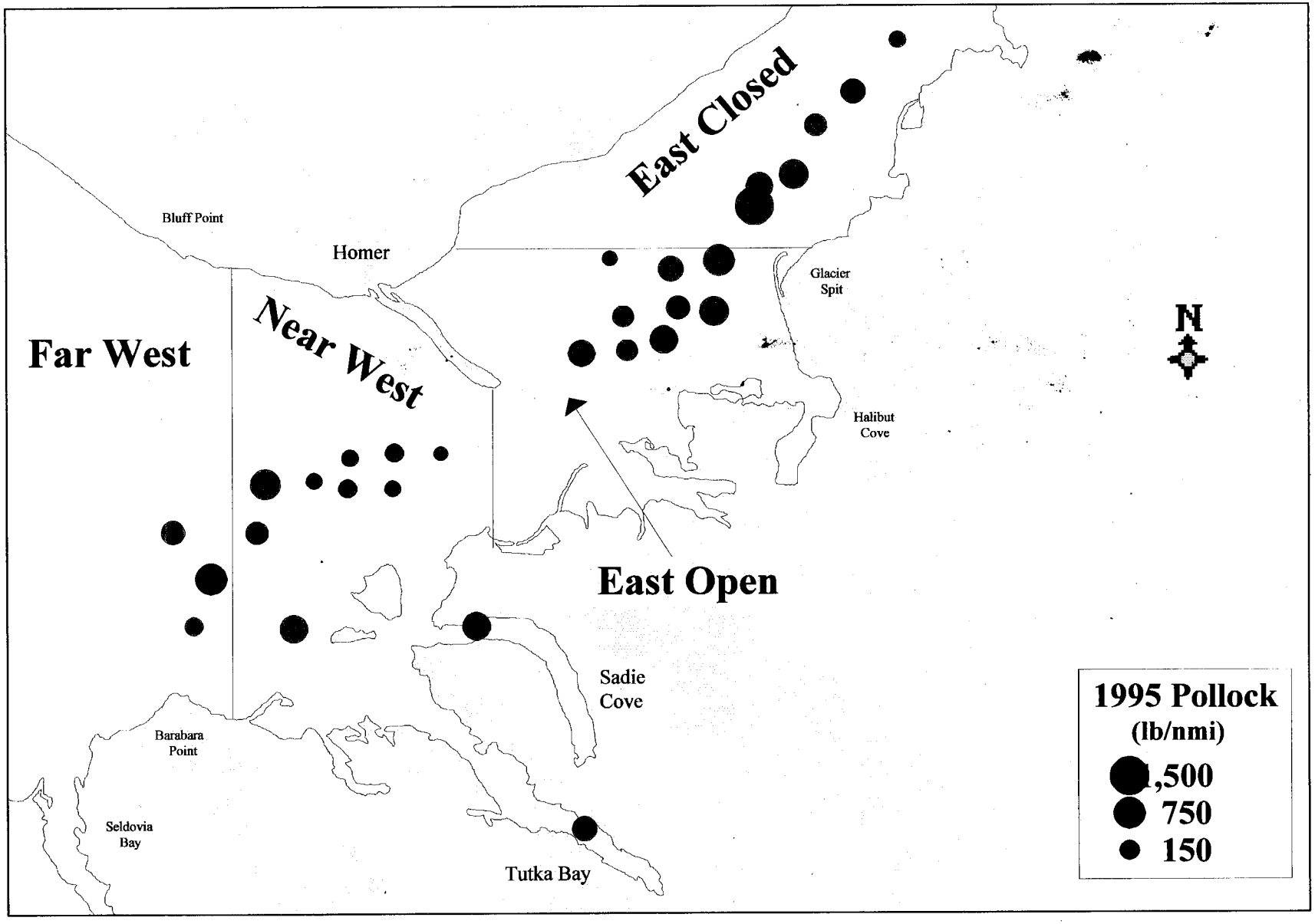

Figure 6. Walleye pollock catch rates in the Kachemak Bay trawl shrimp survey, 1995.

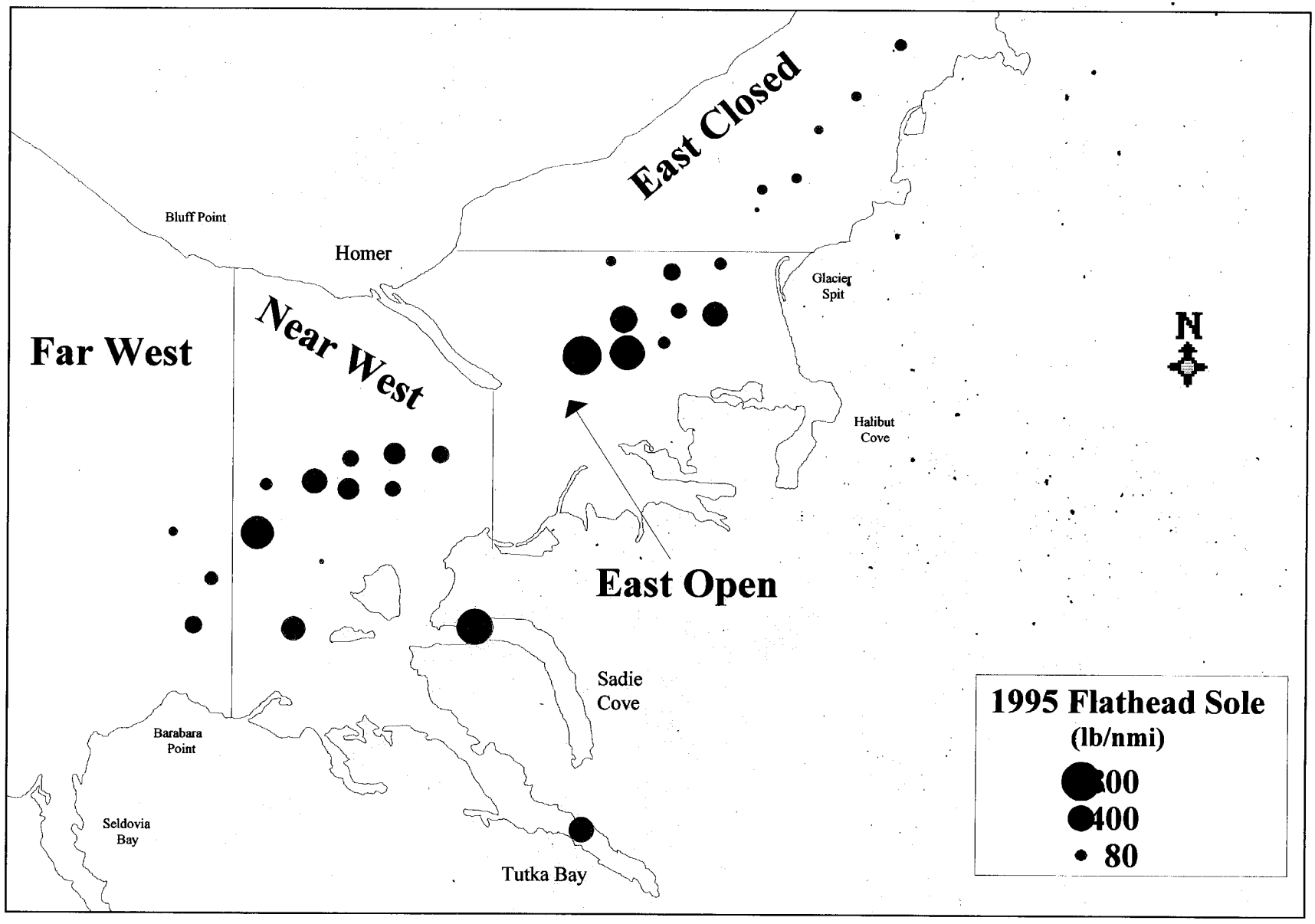

Figure 7. Flathead sole catch rates in the Kachemak Bay trawl shrimp survey, 1995.

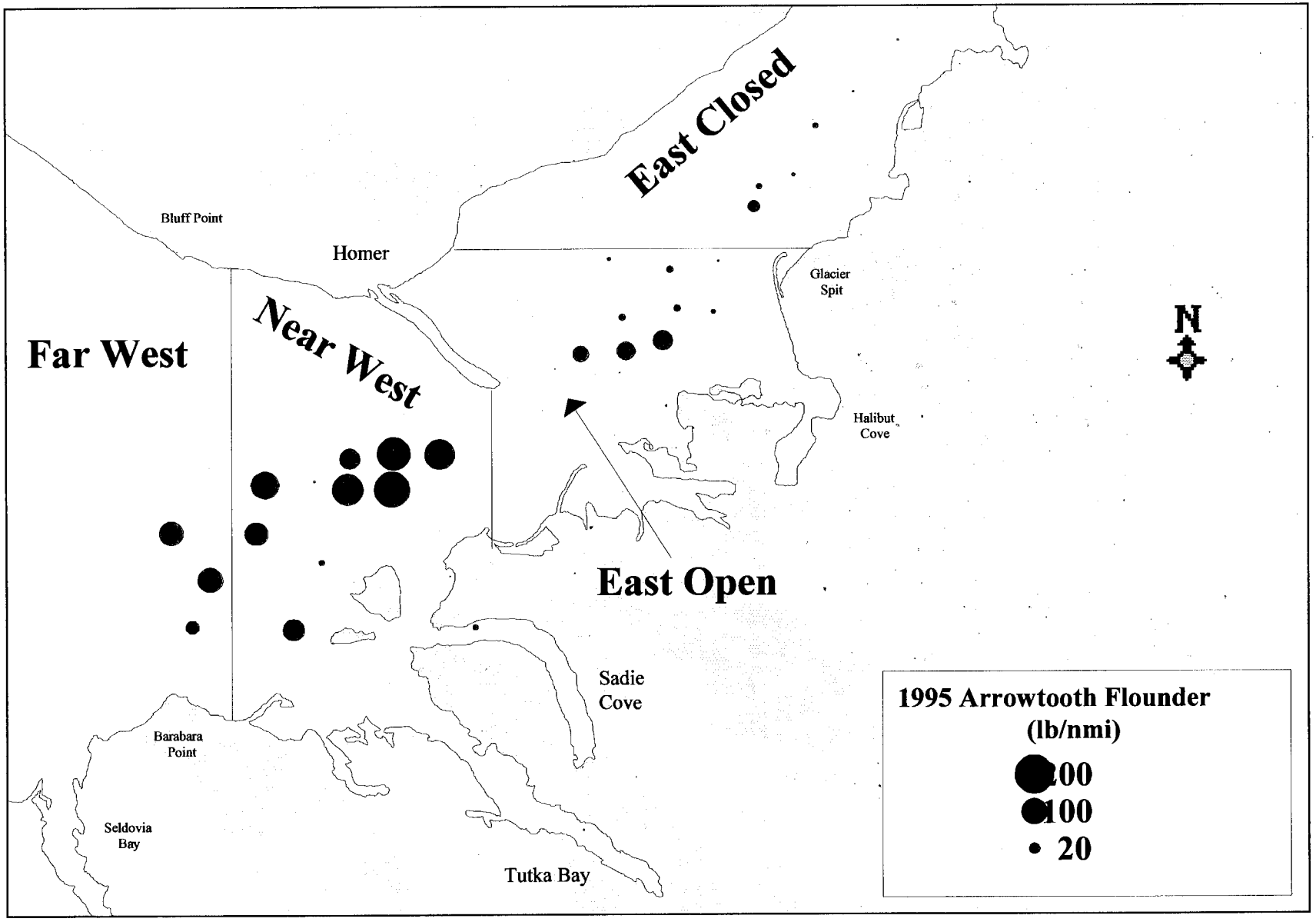

Figure 8. Arrowtooth flounder catch rates in the Kachemak Bay trawl shrimp survey, 1995.

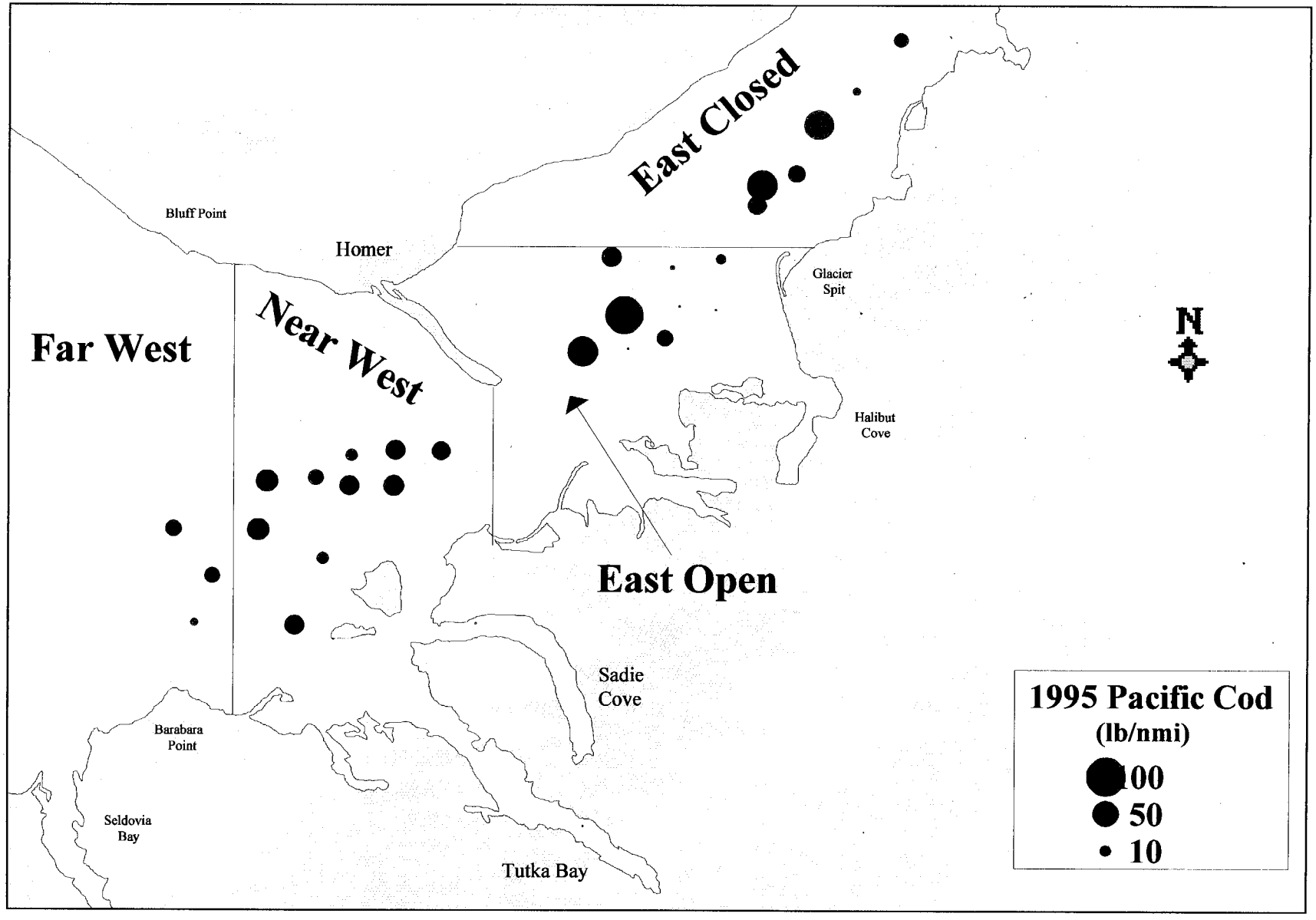

Figure 9. Pacific cod catch rates in the Kachemak Bay trawl survey, 1995.

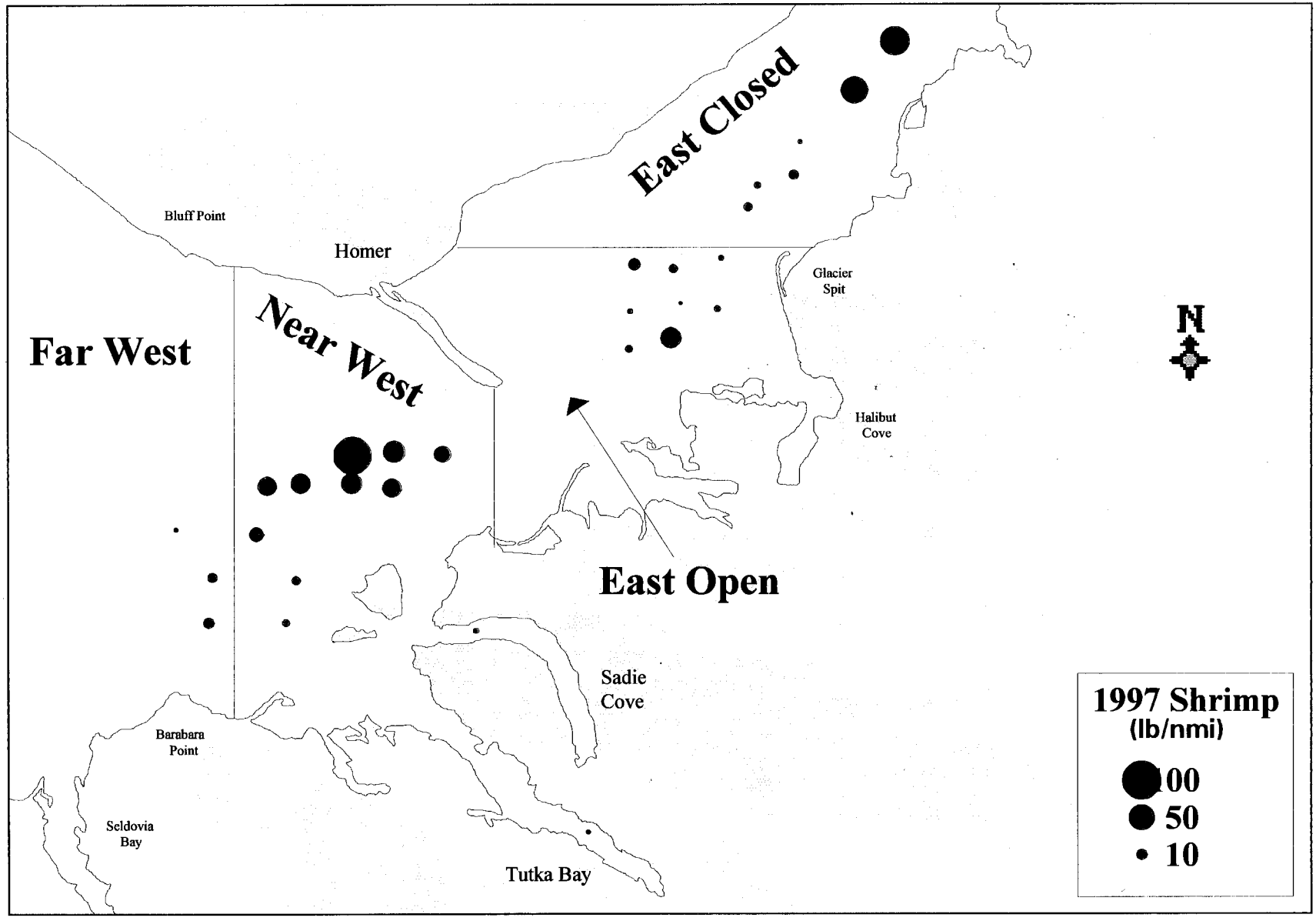

Figure 10. Pandalid shrimp catch rates in the Kachemak Bay trawl shrimp survey, 1997.

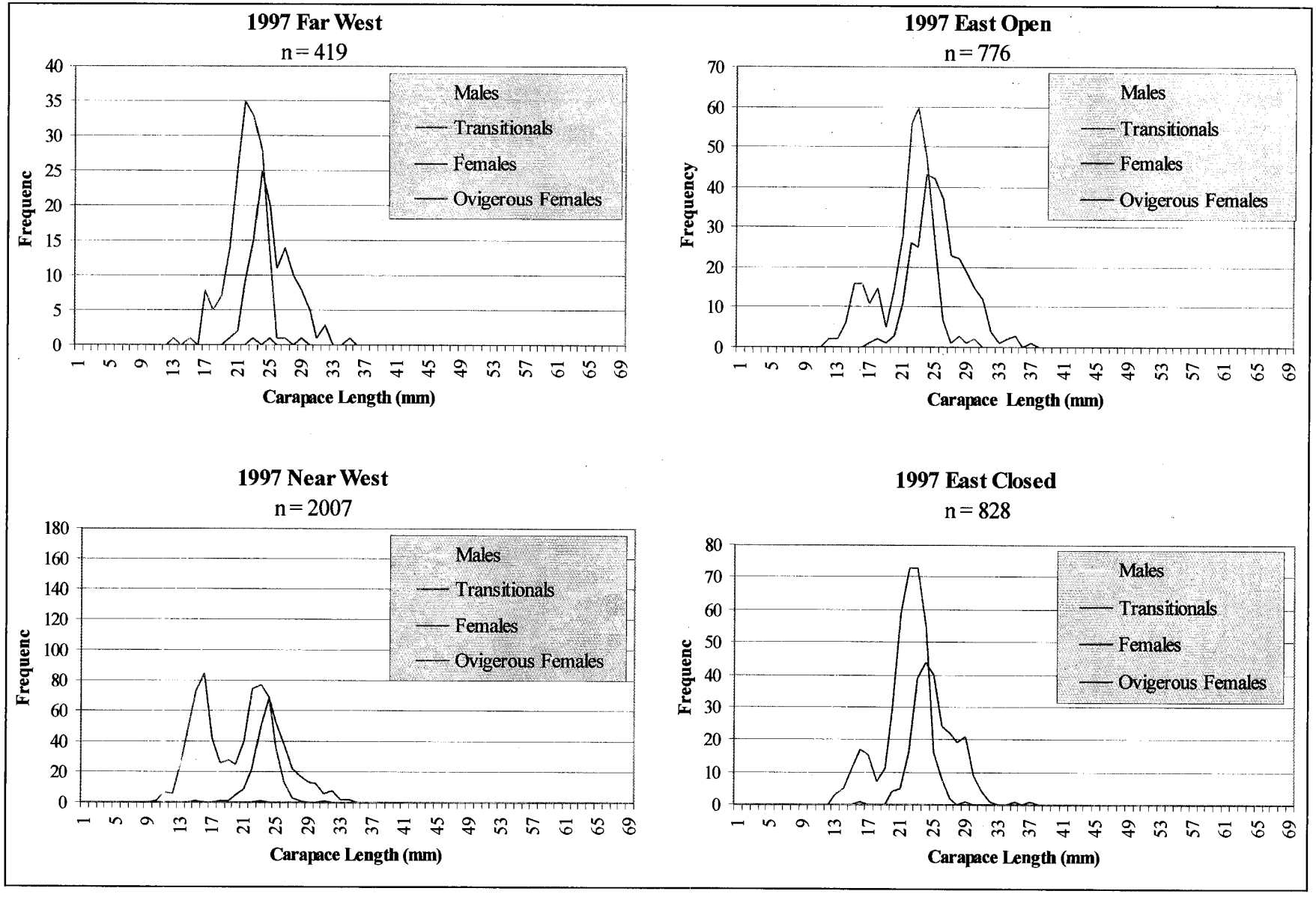

Figure 11. Pink shrimp length frequency by sex and strata in the Kachemak Bay trawl shrimp survey, 1997.

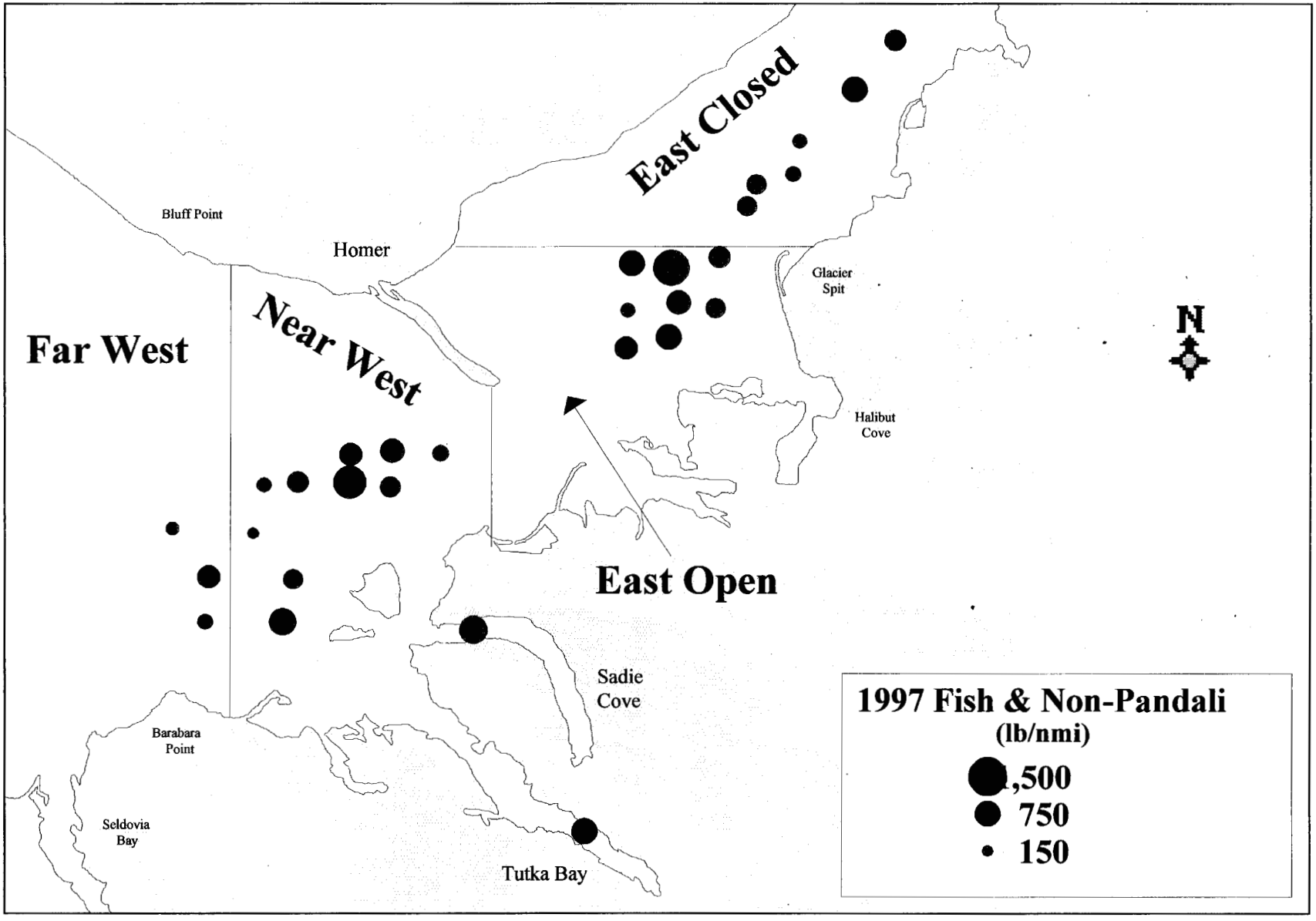

Figure 12. Non-pandalid catch rates by station in the Kachemak Bay trawl shrimp survey, 1997.

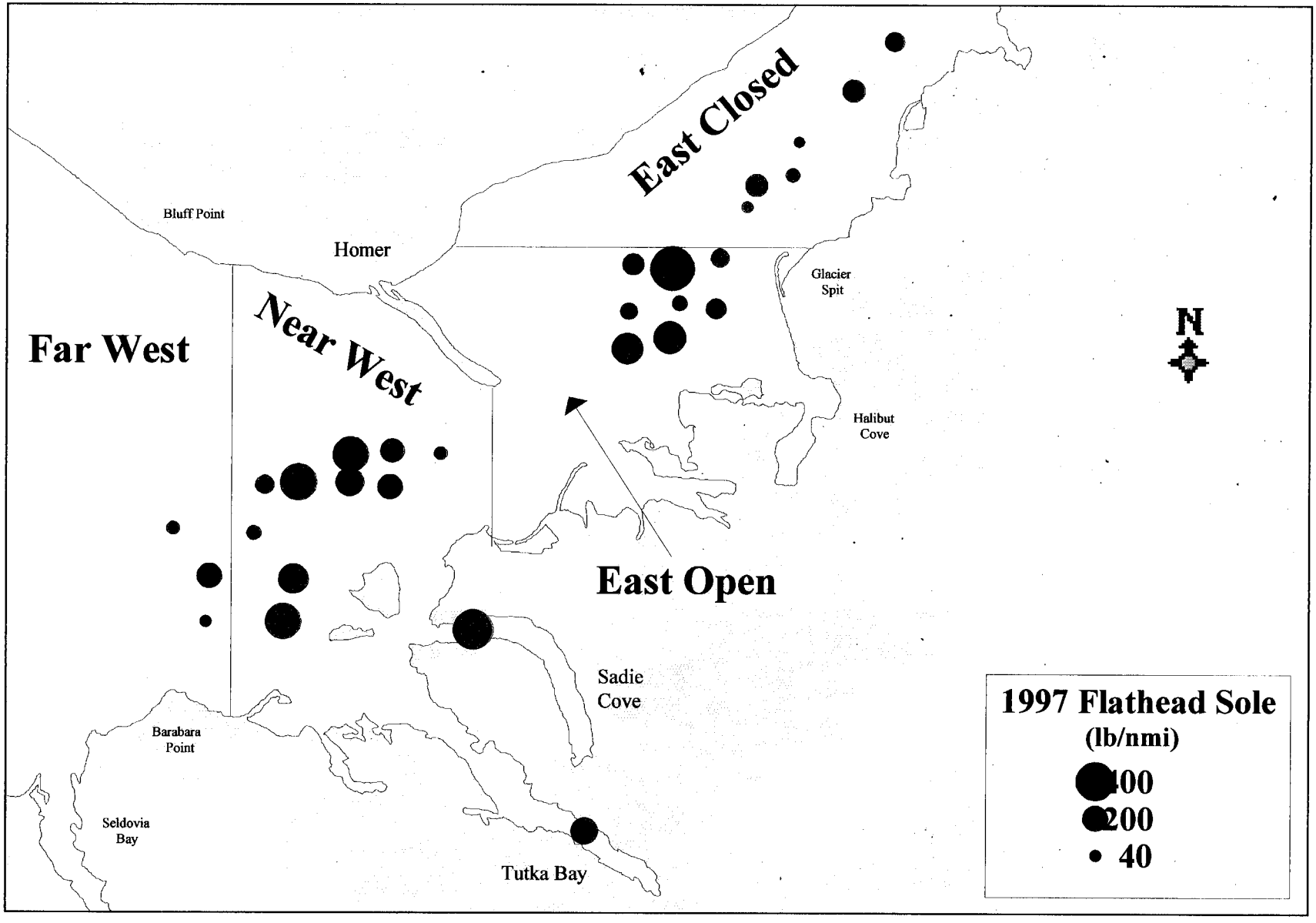

Figure 13. Flathead sole catch rates in the Kachemak Bay trawl shrimp survey, 1997.

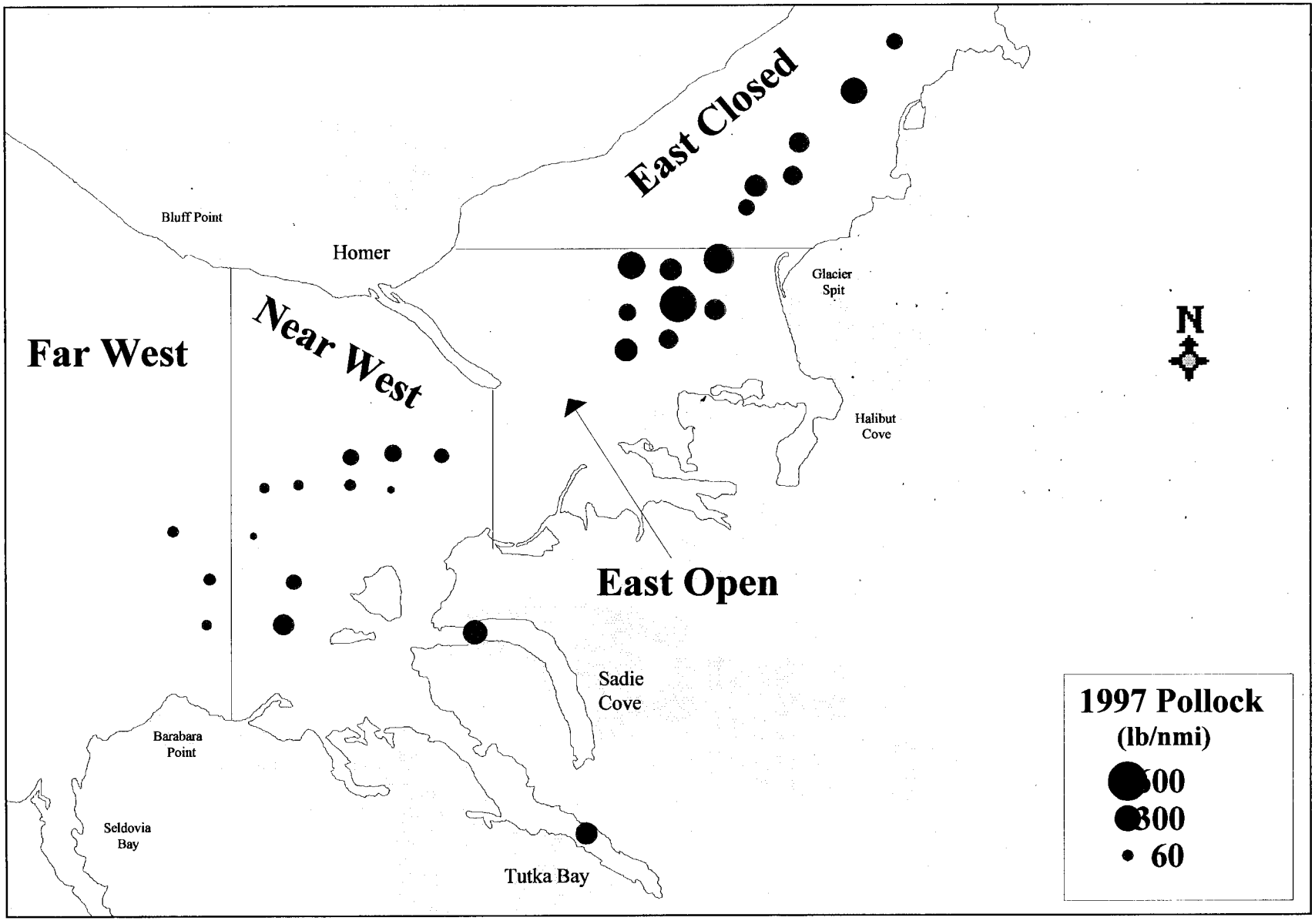

Figure 14. Walleye pollock catch rates in the Kachemak Bay trawl shrimp survey, 1997.

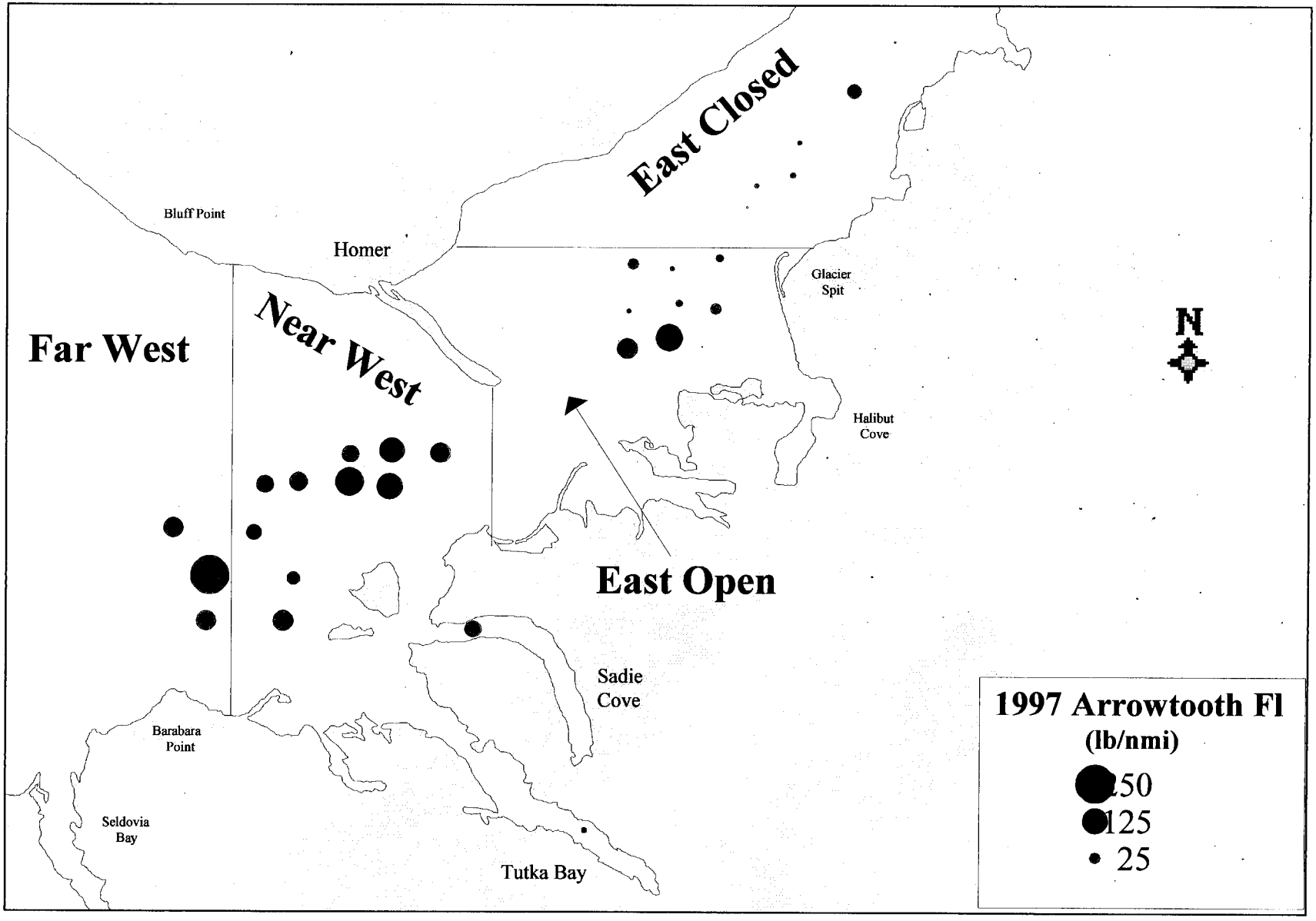

Figure 15. Arrowtooth flounder catch rates in the Kachemak Bay trawl shrimp survey, 1997.

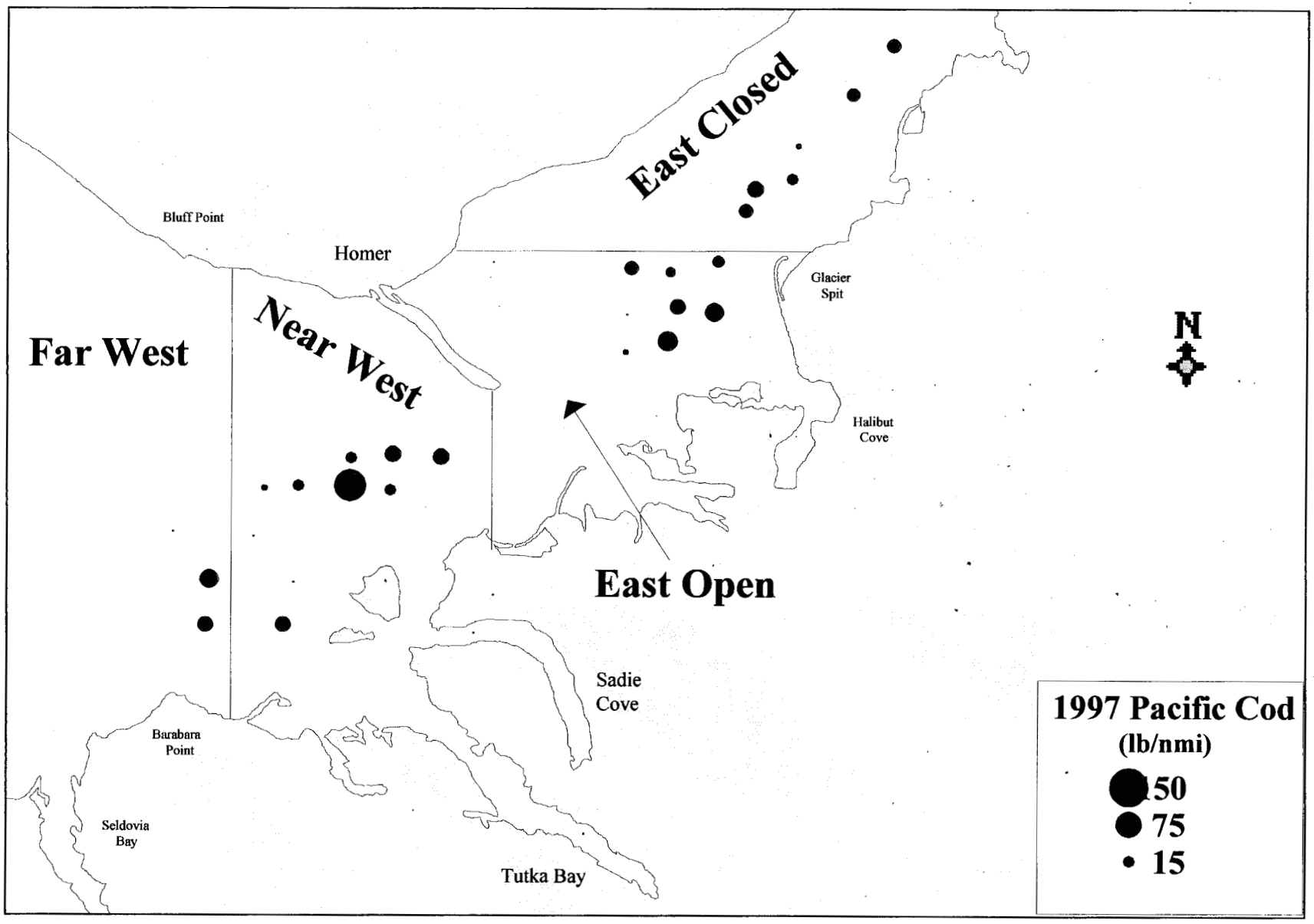

Figure 16. Pacific cod catch rates in the Kachemak Bay trawl shrimp survey, 1997.

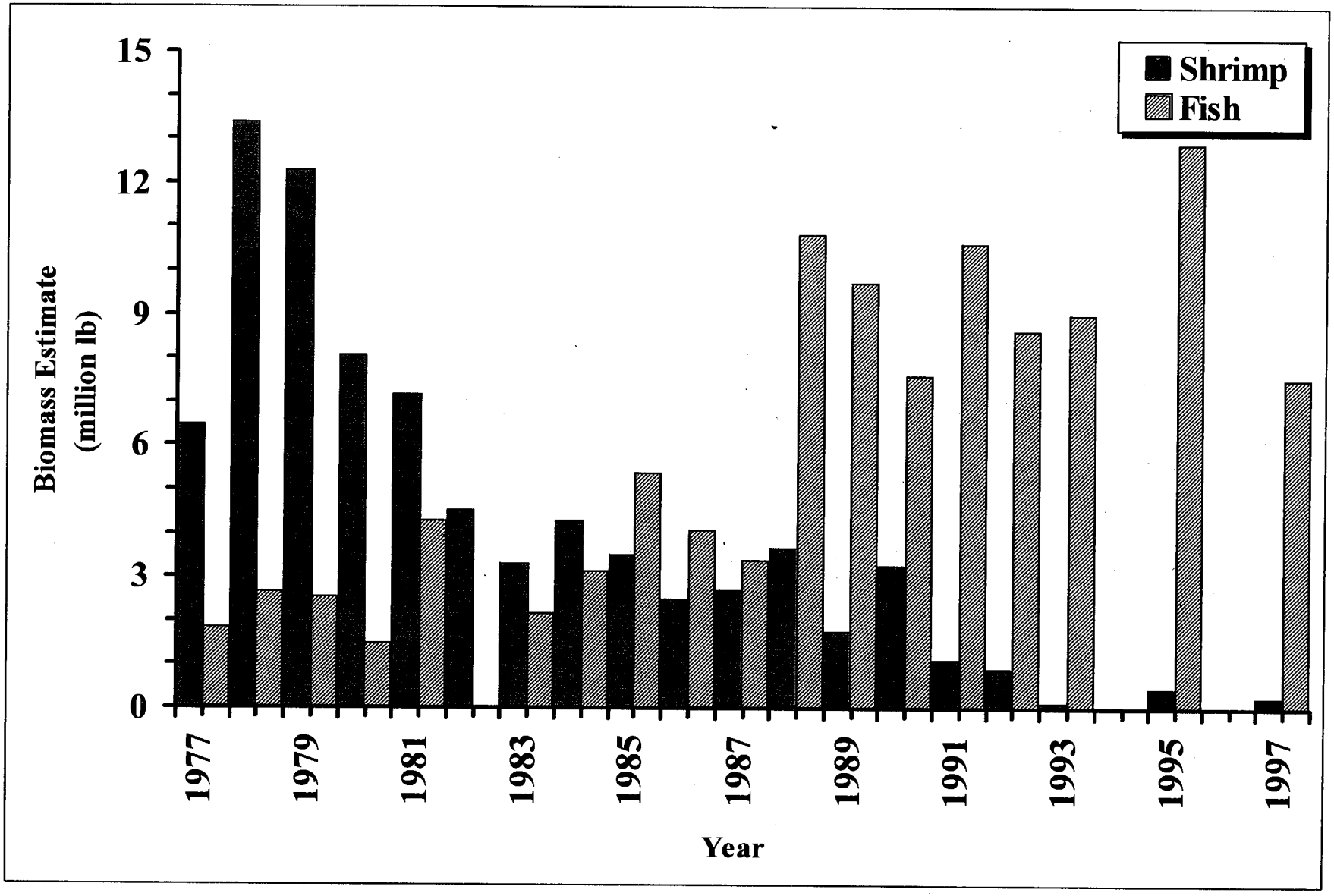

Figure 17. Index biomass estimates of pandalid shrimp and fish in the Kachemak Bay spring trawl shrimp surveys, 1977-1997.

Appendix A. Tow description for the Kachemak Bay shrimp index survey, 22-31 May 1995.

Tow Id.	Date	Station	Tow Start Location		Tow End Location		Tow Duration (Minutes)	Tow Length (nmi)	Course (° True)	Bottom Depth (fathom)		Weight (lb)
			N. Latitude	W. Longitude	N. Latitude	W. Longitude				Min.	Max.	
95101	5/22	O-21	59° 37.24'	151°19.92'	59° 37.56'	151° 18.12'	28	1.0	035	37	37	968
95102	5/22	R-24	59° 40.07'	151° 13.81'	59° 40.51'	151° 12.18'	31	1.0	035	29	30	896
95103	5/22	U-27	59° 43.26'	151° 07.76'	59° 43.78'	151° 06.08'	28	1.0	025	25	27	980
95104	5/23	P-21	59° 38.42'	151° 19.94'	59° 38.97'	151° 19.26'	20	0.6	035	14	16	290
95105	5/24	P-22	59° 38.68'	151° 15.99'	59° 38.23'	151° 17.83'	32	1.0	205	29	29	4,360
95106	5/24	T-26	59° 42.70'	151° 08.07'	59° 42.04'	151° 09.66'	27	1.0	195	30	35	1,038
95107	5/24	S-25	59° 42.01'	151° 09.91'	59° 41.25'	151° 01.10'	25	1.0	200	27	29	622
95108	5/24	R-25	59° 40.29'	151° 12.33'	59° 40.80'	151° 10.61'	25	1.0	038	30	31	832
95109	5/24	Q-24	59° 39.82'	151° 14.23'	59° 39.87'	151° 12.19'	28	1.0	065	29	35	1,910
95110	5/25	N-20	59° 36.92'	151° 20.07'	59° 36.26'	151° 21.60'	28	1.0	205	37	41	1,692
95111	5/25	N-21	59° 36.94'	151° 18.03'	59° 36.36'	151° 19.66'	26	1.0	205	40	42	988
95112	5/25	O-22	59° 37.97'	151° 15.85'	59° 37.22'	151° 17.31'	28	1.0	205	36	41	528
95113	5/25	P-23	59° 38.93'	151° 13.89'	59° 38.36'	151° 15.65'	25	1.0	205	30	34	1,082
95114	5/25	N-22	59° 36.91'	151° 16.16'	59° 36.87'	151° 18.28'	25	1.0	230	41	47	1,012
95115	5/25	O-23	59° 37.90'	151° 14.24'	59° 37.15'	151° 15.76'	27	1.0	190	36	41	1,026
95116	5/25	L-17	59° 34.47'	151° 26.03'	59° 34.25'	151° 27.99'	26	1.0	220	66	67	720
95117	5/26	L-16	59° 34.54'	151° 28.07'	59° 34.23'	151° 30.00'	28	1.0	210	56	60	816
95118	5/26	L-15	59° 34.45'	151° 30.02'	59° 34.08'	151° 31.92'	27	1.0	205	55	60	600
95119	5/26	K-14	59° 33.92'	151° 31.56'	59° 33.61'	151° 33.51'	28	1.0	205	58	64	754
95120	5/26	K-13	59° 34.09'	151° 34.06'	59° 33.30'	151° 35.31'	26	1.0	190	52	53	872

Appendix A. (p. 2 of 2)

Tow Id.	Date	Station	Tow Start Location		Tow End Location		Tow Duration (Minutes)	Tow Length (nmi)	Course (° True)	Bottom Depth (fathom)		Weight (lb)
			N. Latitude	W. Longitude	N. Latitude	W. Longitude				Min.	Max.	
95121	5/26	J-13	59° 32.42'	151° 35.98'	59° 32.80'	151° 34.14'	28	1.0	045	62	67	1,236
95122	5/30	H-18	59° 30.43'	151° 26.49'	59° 30.60'	151° 24.45'	26	1.0	065	35	41	1,666
95123	5/30	C/D-20	59° 25.70'	151° 19.90'	59° 26.27'	151° 21.60'	26	1.0	280	40	47	1,004
95124	5/30	H-14	59° 29.96'	151° 33.46'	59° 30.98'	151° 33.43'	27	1.0	320	43	43	1,936
95125	5/30	I-14	59° 32.11'	151° 31.76'	59° 31.82'	151° 32.67'	17	0.5	200	30	41	205
95126	5/31	K-16	59° 33.71'	151° 28.11'	59° 33.47'	151° 30.11'	27	1.0	225	91	92	874
95127	5/31	K-15	59° 33.78'	151° 30.10'	59° 33.39'	151° 32.02'	29	1.0	220	75	76	860
95128	5/31	H-11/12	59° 30.57'	151° 38.85'	59° 30.51'	151° 36.85'	26	1.0	070	54	62	598
95129	5/31	I-12	59° 31.69'	151° 36.58'	59° 31.49'	151° 37.55'	15	0.5	220	57	58	1,024
95130	5/31	J-11	59° 32.75'	151° 38.32'	59° 32.52'	151° 39.24'	14	0.5	215	45	48	516

Appendix B. Tow description for the Kachemak Bay shrimp index survey, 27 May – 2 June 1997.

Tow Id.	Date	Station	Tow Start Location		Tow End Location		Tow Duration (Minutes)	Tow Length (nmi)	Course (° True)	Bottom Depth (fathom)		Weight (lb)
			N. Latitude	W. Longitude	N. Latitude	W. Longitude				Min.	Max.	
97001	5/27	N-20	59° 36.95'	151° 19.77'	59° 63.32'	151° 21.46'	30	1.0	200	36	40	434
97002	5/27	O-22	59° 38.06'	151° 15.74'	59° 37.31'	151° 17.40'	27	1.0	200	34	40	838
97003	5/28	L-17	59° 34.45'	151° 25.98'	59° 34.22'	151° 27.99'	25	1.0	215	68	69	600
97004	5/28	K-15	59° 33.91'	151° 30.02'	59° 33.47'	151° 31.89'	30	1.0	212	72	75	1,472
97005	5/28	I-14	59° 31.64'	151° 32.88'	59° 31.45'	151° 33.94'	14	0.5	195	43	51	440
97006	5/28	H-14	59° 30.09'	151° 33.79'	59° 31.10'	151° 33.95'	30	1.0	333	45	46	1,090
97007	5/28	H-12	59° 30.59'	151° 37.75'	59° 30.60'	151° 36.73'	16	0.5	080	60	61	506
97008	5/28	I-12	59° 31.73'	151° 36.63'	59° 31.49'	151° 37.54'	18	0.5	208	56	56	512
97009	5/29	P-21	59° 38.82'	151° 17.77'	59° 38.26'	151° 19.42'	27	1.0	200	17	19	1,092
97010	5/29	R-24	59° 40.07'	151° 14.07'	59° 40.50'	151° 12.32'	29	1.0	035	29	29	704
97011	5/29	S-25	59° 40.98'	151° 12.13'	59° 41.51'	151° 10.50'	27	1.0	035	26	27	500
97012	5/29	U-27	59° 43.24'	151° 07.99'	59° 43.72'	151° 06.30'	27	1.0	025	25	27	1,206
97013	5/29	T-26	59° 42.64'	151° 08.08'	59° 42.13'	151° 09.76'	28	1.0	200	28	35	1,724
97014	5/29	R-25	59° 40.26'	151° 12.66'	59° 40.77'	151° 10.52'	31	1.0	030	28	28	548
97015	5/30	P-22	59° 38.65'	151° 15.98'	59° 38.25'	151° 17.78'	32	1.0	210	29	30	2,396
97016	5/30	Q-24	59° 39.78'	151° 14.09'	59° 39.83'	151° 13.10'	12	0.5	100	27	29	468
97017	5/30	P-23	59° 38.94'	151° 13.91'	59° 38.42'	151° 15.68'	28	1.0	200	31	33	842
97018	5/30	O-23	59° 37.90'	151° 14.22'	59° 37.23'	151° 15.69'	26	1.0	200	35	39	716
97019	5/30	N-22	59° 36.91'	151° 16.00'	59° 36.92'	151° 18.00'	27	1.0	235	40	42	1,032
97020	5/31	L-16	59° 34.53'	151° 28.18'	59° 34.26'	151° 29.98'	29	1.0	220	58	62	964

Appendix B. (p. 2 of 2)

Tow Id.	Date	Station	Tow Start Location		Tow End Location		Tow Duration (Minutes)	Tow Length (nmi)	Course (° True)	Bottom Depth (fathom)		Weight (lb)
			N. Latitude	W. Longitude	N. Latitude	W. Longitude				Min.	Max.	
97021	5/31	L-15	59°34.50'	151° 30.00'	59° 34.12'	151° 31.82'	27	1.0	200	55	61	956
97022	5/31	K-14	59° 33.80'	151° 32.23'	59° 33.58'	151° 34.18'	27	1.0	210	56	64	838
97023	5/31	K-13	59° 33.99'	151° 34.04'	59° 33.27'	151° 35.35'	26	1.0	190	53	53	532
97024	5/31	J-11	59° 32.75'	151° 38.22'	59° 32.59'	151° 39.17'	12	0.5	200	44	47	320
97025	5/31	J-13	59° 32.39'	151° 36.09'	59° 32.74'	151° 34.22'	26	1.0	060	60	66	370
97026	5/31	K-16	59° 33.71'	151° 28.17'	59° 33.46'	151° 30.20'	25	1.0	220	92	93	710
97027	6/2	O-21	59° 37.69'	151° 17.90'	59° 37.31'	151° 19.69'	25	1.0	215	35	35	526
97028	6/2	N-21	59° 36.99'	151° 18.06'	59° 36.36'	151° 19.62'	27	1.0	200	40	41	854
97029	6/2	C/D-20	59° 25.63'	151° 19.81'	59° 26.24'	151° 21.44'	27	1.0	289	41	49	1,106
97030	6/2	H-18	59° 30.36'	151° 26.52'	59° 30.46'	151° 24.54'	26	1.0	078	40	46	1,122

Appendix C. Species biomass composition ranking among stations during the Kachemak Bay trawl shrimp survey, 1995.

Rank	Common Name	*Species Name*	*Percent*
	Total fish		82.3
	Commercial Pandalid Shrimp		3.8
1	Walleye Pollock	*Theragra chalcogramma*	33.4
2	Flathead Sole	*Hippoglossoides elassodon*	22.7
3	Arrowtooth Flounder	*Atheresthes stomias*	4.3
4	Sculpin	Family Cottidae	3.7
5	Pink Shrimp	*Pandalus borealis*	3.6
6	Tanner Crab	*Chionoecetes bairdi*	2.4
7	Pacific Cod	*Gadus macrocephalus*	2.3
8	Starry Flounder	*Platichthys stellatus*	2.1
9	Pacific Tomcod	*Microgadus proximus*	1.9
10	Pacific Halibut	*Hippoglossus stenolepis*	1.8
11	Skate	Family Rajidae	1.3
12	Dover Sole	*Microstomus pacificus*	1.2
13	Yellowfin Sole	*Limanda aspera*	0.7
14	Sea Star	Phylum Echinodermata	0.6
15	Dungeness Crab	*Cancer magister*	0.6
16	Rougheye Rockfish	*Sebastes aleutianus*	0.5
17	Sea Anemone	Order Actiniaria	0.5
18	Rex Sole	*Glyptocephalus zachirus*	0.4
19	Alaska Plaice	*Pleuronectes quadrituberculatus*	0.3
20	Green Urchin	*Strongylocentrotus droebachiensis*	0.2
21	Eulachon	*Thaleichthys pacificus*	0.2
22	Snail	Orders Mesogastropoda/Neogastropoda	0.2
23	Eelpout	*Lycodes* species	0.2
24	Jellyfish	Class Scyphozoa	0.1
25	Sidestripe Shrimp	*Pandalopsis dispar*	0.1
26	Other Shrimp	*Crangon, Eualus, Lebbeus, Sclerocrangon*	0.1
36	Coonstripe Shrimp	*Pandalus hypsinotus*	<0.1
42	Humpy Shrimp	*Pandalus goniurus*	<0.1
NR	Other Animals	Included 26 species this survey.	0.8
NR	Debris		13.8
	Total		100.0

NR = Not Ranked

Appendix D. Species biomass composition ranking in the Far West Stratum during the Kachemak Bay trawl shrimp survey, 1995.

Rank	Common Name	*Species Name*	*Percent*
	Total fish		97.4
	Commercial Pandalid Shrimp		1.2
1	Walleye Pollock	*Theragra chalcogramma*	47.3
2	Flathead Sole	*Hippoglossoides elassodon*	20.2
3	Arrowtooth Flounder	*Atheresthes stomias*	8.6
4	Skate	Family Rajidae	6.2
5	Dover Sole	*Microstomus pacificus*	4.6
6	Rex Sole	*Glyptocephalus zachirus*	2.2
7	Green Urchin	*Strongylocentrotus droebachiensis*	2.1
8	Pacific Cod	*Gadus macrocephalus*	2.0
9	Pink Shrimp	*Pandalus borealis*	1.2
10	Rougheye Rockfish	*Sebastes aleutianus*	1.1
11	Pacific Halibut	*Hippoglossus stenolepis*	0.6
12	Spiny Dogfish	*Squalus acanthias*	0.6
13	Tanner Crab	*Chionoecetes bairdi*	0.5
14	Sculpin	Family Cottidae	0.3
15	Eelpout	*Lycodes* species	0.3
16	Sea Star	Phylum Echinodermata	0.2
17	Sea Anemone	Order Actiniaria	0.2
18	Eulachon	*Thaleichthys pacificus*	0.2
19	Sea Cucumber	*Parastichopus californicus*	0.1
20	Snail	Orders Mesogastropoda/Neogastropoda	<0.1
21	Dusky Rockfish	*Sebastes ciliatus*	<0.1
22	Other Shrimp	*Crangon, Eualus, Lebbeus, Sclerocrangon*	<0.1
23	Sidestripe Shrimp	*Pandalopsis dispar*	<0.1
NR	Debris		1.5
	Total		100.0

NR = Not Ranked

Appendix E. Species biomass composition ranking in the Near West Stratum during the Kachemak Bay trawl shrimp survey, 1995.

Rank	Common Name	*Species Name*	*Percent*
	Total fish		89.0
	Commercial Pandalid Shrimp		5.5
1	Flathead Sole	*Hippoglossoides elassodon*	27.8
2	Walleye Pollock	*Theragra chalcogramma*	22.1
3	Arrowtooth Flounder	*Atheresthes stomias*	10.3
4	Pink Shrimp	*Pandalus borealis*	5.1
5	Sculpin	Family Cottidae	4.8
6	Tanner Crab	*Chionoecetes bairdi*	4.8
7	Pacific Cod	*Gadus macrocephalus*	3.0
8	Dover Sole	*Microstomus pacificus*	2.8
9	Skate	Family Rajidae	2.4
10	Sea Star	Phylum Echinodermata	1.9
11	Rougheye Rockfish	*Sebastes aleutianus*	1.6
12	Pacific Halibut	*Hippoglossus stenolepis*	1.4
13	Sea Anemone	Order Actiniaria	1.4
14	Alaska Plaice	*Pleuronectes quadrituberculatus*	0.7
15	Rex Sole	*Glyptocephalus zachirus*	0.6
16	Snail	Orders Mesogastropoda/Neogastropoda	0.5
17	Sidestripe Shrimp	*Pandalopsis dispar*	0.4
18	Jellyfish	Class Scyphozoa	0.4
19	Rock Sole	*Lepidopsetta bilineata*	0.3
20	Pink Scallop	*Chlamys* species	0.3
21	Eulachon	*Thaleichthys pacificus*	0.3
22	Sablefish	*Anoplopoma fimbria*	0.2
23	Green Urchin	*Strongylocentrotus droebachiensis*	0.2
24	Other Shrimp	*Crangon, Eualus, Lebbeus, Sclerocrangon*	0.2
25	Eelpout	*Lycodes* species	0.2
26	Red King Crab	*Paralithodes camtschatica*	0.2
NR	Other Animal	Included 14 species this tow.	0.8
NR	Debris		5.2
	Total		100.0

NR = Not Ranked

Appendix F. Species biomass composition ranking in the East Open Stratum during the Kachemak Bay trawl shrimp survey, 1995.

Rank	Common Name	*Species Name*	*Percent*
	Total fish		66.3
	Commercial Pandalid Shrimp		3.8
1	Walleye Pollock	*Theragra chalcogramma*	29.4
2	Flathead Sole	*Hippoglossoides elassodon*	24.3
3	Pink Shrimp	*Pandalus borealis*	3.7
4	Tanner Crab	*Chionoecetes bairdi*	2.4
5	Sculpin	Family Cottidae	2.3
6	Pacific Cod	*Gadus macrocephalus*	1.9
7	Arrowtooth Flounder	*Atheresthes stomias*	1.6
8	Dungeness Crab	*Cancer magister*	1.4
9	Pacific Tomcod	*Microgadus proximus*	1.1
10	Pacific Halibut	*Hippoglossus stenolepis*	0.4
11	Skate	Family Rajidae	0.4
12	Yellowfin Sole	*Limanda aspera*	0.2
13	Eelpout	*Lycodes* species	0.2
14	Sea Anemone	Order Actiniaria	0.2
15	Starry Flounder	*Platichthys stellatus*	0.1
16	Sea Football	*Cucumaria fallax*	0.1
17	Eulachon	*Thaleichthys pacificus*	0.1
18	Other Shrimp	*Crangon, Eualus, Lebbeus, Sclerocrangon*	0.1
19	Snail	Orders Mesogastropoda/Neogastropoda	<0.1
20	Pink Scallop	Chlamys species	<0.1
21	Coonstripe Shrimp	*Pandalus hypsinotus*	<0.1
22	Humpy Shrimp	*Pandalus goniurus*	<0.1
23	Majestic Squid	Berryteuthis magister	<0.1
24	Rex Sole	*Glyptocephalus zachirus*	<0.1
25	Rougheye Rockfish	*Sebastes aleutianus*	<0.1
26	Butter Sole	*Isopsetta isolepis*	<0.1
27	Prickleback	Family Stichaeidae	<0.1
28	Other Crab	Infraorder Brachyura/Anomura	<0.1
29	Poacher	Family Agonidae	<0.1
30	Starsnout	*Bathyagonus* species	<0.1
31	Sidestripe Shrimp	*Pandalopsis dispar*	<0.1
NR	Debris		29.9
	Total		100.0

NR = Not Ranked

Appendix G. Species biomass composition ranking in the East Closed Stratum during the Kachemak Bay trawl shrimp survey, 1995.

Rank	Common Name	*Species Name*	Percent
	Total Fish		89.2
	Commercial Pandalid Shrimp		3.5
1	Walleye Pollock	*Theragra chalcogramma*	50.9
2	Starry Flounder	*Platichthys stellatus*	10.1
3	Pacific Tomcod	*Microgadus proximus*	7.6
4	Flathead Sole	*Hippoglossoides elassodon*	6.2
5	Pacific Halibut	*Hippoglossus stenolepis*	4.8
6	Pink Shrimp	*Pandalus borealis*	3.4
7	Pacific Cod	*Gadus macrocephalus*	3.1
8	Sculpin	Family Cottidae	2.2
9	Yellowfin Sole	*Limanda aspera*	0.8
10	Arrowtooth Flounder	*Atheresthes stomias*	0.7
11	Alaska Plaice	*Pleuronectes quadrituberculatus*	0.6
12	Eulachon	*Thaleichthys pacificus*	0.4
13	Tanner Crab	*Chionoecetes bairdi*	0.4
14	Dungeness Crab	*Cancer magister*	0.4
15	Red King Crab	*Paralithodes camtschatica*	0.2
16	Other Shrimp	*Crangon, Eualus, Lebbeus, Sclerocrangon*	0.2
17	Skate	Family Rajidae	0.2
18	Poacher	Family Agonidae	0.1
19	Coonstripe Shrimp	*Pandalus hypsinotus*	0.1
20	Weathervane Scallop	*Patinopecten caurinus*	0.1
21	Sablefish	*Anoplopoma fimbria*	0.1
22	Snail	Orders Mesogastropoda/Neogastropoda	0.1
23	Rock Sole	*Lepidopsetta bilineata*	0.1
24	Jellyfish	Class Scyphozoa	<0.1
25	Humpy Shrimp	*Pandalus goniurus*	<0.1
26	Pacific Herring	*Clupea pallasi*	<0.1
27	Eelpout	*Lycodes* species	<0.1
28	Sandfish	*Trichodon trichodon*	<0.1
29	Sidestripe Shrimp	*Pandalopsis dispar*	<0.1
30	Rex Sole	*Glyptocephalus zachirus*	<0.1
NR	Debris		7.2
	Total		100.0

NR = Not Ranked

Appendix H. Species biomass composition ranking in the Tutka Bay and Sadie Cove stations during the Kachemak Bay trawl shrimp survey, 1995.

Rank	Common Name	*Species Name*	Percent
	Total Fish		98.3
	Commercial Pandalid Shrimp		1.4
1	Flathead Sole	*Hippoglossoides elassodon*	39.6
2	Walleye Pollock	*Theragra chalcogramma*	33.2
3	Sculpin	Family Cottidae	13.2
4	Yellowfin Sole	*Limanda aspera*	5.7
5	Pacific Halibut	*Hippoglossus stenolepis*	3.2
6	Pink Shrimp	*Pandalus borealis*	1.4
7	Starry Flounder	*Platichthys stellatus*	1.0
8	Giant Wrymouth	*Delolepis gigantea*	0.7
9	Tanner Crab	*Chionoecetes bairdi*	0.5
10	Alaska Plaice	*Pleuronectes quadrituberculatus*	0.4
11	Arrowtooth flounder	*Atheresthes stomias*	0.3
12	Sea Star	Phylum Echinodermata	0.2
13	Rex Sole	*Glyptocephalus zachirus*	0.1
14	Rock Sole	*Lepidopsetta bilineata*	0.1
15	Other Shrimp	*Crangon, Eualus, Lebbeus, Sclerocrangon*	<0.1
16	Sablefish	*Anoplopoma fimbria*	<0.1
17	Coonstripe Shrimp	*Pandalus hypsinotus*	<0.1
18	Eelpout	*Lycodes* species	<0.1
19	Clam	Class Bivalvia	<0.1
20	Pink Scallop	Chlamys species	<0.1
21	Rougheye Rockfish	*Sebastes aleutianus*	<0.1
22	Prickleback	Family Stichaeidae	<0.1
23	Saffron Cod	*Eleginus gracilis*	<0.1
NR	Debris		0.2
	Total		100.0

NR = Not Ranked

Appendix I. Species biomass composition ranking among all stations during the Kachemak Bay trawl shrimp survey, 1997.

Rank	Common Name	Species Name	Percent
	Total Fish		84.7
	Commercial Pandalid Shrimp		2.8
1	Flathead Sole	*Hippoglossoides elassodon*	28.0
2	Walleye Pollock	*Theragra chalcogramma*	26.4
3	Arrowtooth Flounder	*Atheresthes stomias*	8.6
4	Tanner Crab	*Chionoecetes bairdi*	5.1
5	Pacific Cod	*Gadus macrocephalus*	3.3
6	Pink Shrimp	*Pandalus borealis*	2.6
7	Sculpin	Family Cottidae	2.3
8	Skate	Family Rajidae	2.1
9	Pacific Halibut	*Hippoglossus stenolepis*	1.9
10	Sea Anemone	Order Actiniaria	0.7
11	Starry Flounder	*Platichthys stellatus*	0.6
12	Yellowfin Sole	*Limanda aspera*	0.6
13	Searcher/Ronquil	Family Bathymasteridae	0.6
14	Rex Sole	*Glyptocephalus zachirus*	0.6
15	Eelpout	*Lycodes* species	0.5
16	Alaska Plaice	*Pleuronectes quadrituberculatus*	0.4
17	Dungeness Crab	*Cancer magister*	0.4
18	Eulachon	*Thaleichthys pacificus*	0.3
19	Dover Sole	*Microstomus pacificus*	0.3
20	Sea Star	Phylum Echinodermata	0.3
21	Weathervane Scallop	*Patinopecten caurinus*	0.2
22	Giant Pacific Octopus	*Octopus dofleini*	0.2
23	Rougheye Rockfish	*Sebastes aleutianus*	0.2
24	Sponge	Phylum Porifera	0.2
25	Other Shrimp	*Crangon, Eualus, Lebbeus, Sclerocrangon*	0.2
26	Rock Sole	*Lepidopsetta bilineata*	0.2
27	Giant Wrymouth	*Delolepis gigantea*	0.2
28	Coonstripe Shrimp	*Pandalus hypsinotus*	0.1
32	Humpy Shrimp	*Pandalus goniurus*	0.1
34	Sidestripe Shrimp	*Pandalopsis dispar*	0.1
NR	Other Animals	Included 21 species this survey.	0.5
NR	Debris		12.4
	Total		100

NR = Not Ranked

Appendix J. Species biomass composition ranking in the Far West Stratum during the Kachemak Bay trawl shrimp survey, 1997.

Rank	Common Name	Species Name	Percent
	Total Fish		98.0
	Commercial Pandalid Shrimp		1.9
1	Arrowtooth Flounder	*Atheresthes stomias*	34.6
2	Flathead Sole	*Hippoglossoides elassodon*	26.8
3	Walleye Pollock	*Theragra chalcogramma*	16.8
4	Pacific Cod	*Gadus macrocephalus*	6.2
5	Tanner Crab	*Chionoecetes bairdi*	3.2
6	Rex Sole	*Glyptocephalus zachirus*	3.2
7	Dover Sole	*Microstomus pacificus*	3.0
8	Pink Shrimp	*Pandalus borealis*	1.9
9	Skate	Family Rajidae	1.6
10	Sablefish	*Anoplopoma fimbria*	1.0
11	Dusky Rockfish	*Sebastes ciliatus*	0.4
12	Rougheye Rockfish	*Sebastes aleutianus*	0.4
13	Green Urchin	*Strongylocentrotus droebachiensis*	0.2
14	Sculpin	Family Cottidae	0.2
15	Eelpout	*Lycodes* species	0.1
16	Other Shrimp	*Crangon, Eualus, Lebbeus, Sclerocrangon*	0.1
17	Starsnout	*Bathyagonus* species	0.1
18	Eulachon	*Thaleichthys pacificus*	<0.1
19	Red Urchin	*Strongylocentrotus franciscanus*	<0.1
20	Searcher/Ronquil	Family Bathymasteridae	<0.1
21	Humpy Shrimp	*Pandalus goniurus*	<0.1
NR	Debris		0.1
	Total		100

NR = Not Ranked

Appendix K. Species biomass composition ranking in the Near West Stratum during the Kachemak Bay trawl shrimp survey, 1997.

Rank	Common Name	Species Name	Percent
	Total Fish		91.4
	Commercial Pandalid Shrimp		5.2
1	Flathead Sole	*Hippoglossoides elassodon*	36.7
2	Walleye Pollock	*Theragra chalcogramma*	15.9
3	Arrowtooth Flounder	*Atheresthes stomias*	14.0
4	Tanner Crab	*Chionoecetes bairdi*	10.3
5	Pink Shrimp	*Pandalus borealis*	5.0
6	Pacific Cod	*Gadus macrocephalus*	4.3
7	Skate	Family Rajidae	4.2
8	Rex Sole	*Glyptocephalus zachirus*	1.1
9	Giant Pacific Octopus	Octopus dofleini	0.7
10	Eelpout	*Lycodes* species	0.6
11	Pacific Halibut	*Hippoglossus stenolepis*	0.5
12	Rougheye Rockfish	*Sebastes aleutianus*	0.5
13	Eulachon	*Thaleichthys pacificus*	0.4
14	Giant Wrymouth	*Delolepis gigantea*	0.4
15	Sculpin	Family Cottidae	0.4
16	Dungeness Crab	*Cancer magister*	0.2
17	Rock Sole	*Lepidopsetta bilineata*	0.2
18	Sidestripe Shrimp	*Pandalopsis dispar*	0.2
19	Dover Sole	*Microstomus pacificus*	0.2
20	Sea Anemone	Order Actiniaria	0.1
21	Other Shrimp	*Crangon, Eualus, Lebbeus, Sclerocrangon*	0.1
22	Alaska Plaice	*Pleuronectes quadrituberculatus*	0.1
23	Prickleback	Family Stichaeidae	0.1
24	Rockfish, Dusky	*Sebastes ciliatus*	0.1
25	Sea Star	Phylum Echinodermata	<0.1
NR	Coonstripe Shrimp	*Pandalus hypsinotus*	<0.1
NR	Other Animals	Included 11 species this tow.	0.2
NR	Debris		3.3
	Total		100

NR = Not Ranked

Appendix L. Species biomass composition ranking in the East Open Stratum during the Kachemak Bay trawl shrimp survey, 1997.

Rank	Common Name	Species Name	Percent
	Total Fish		84.0
	Commercial Pandalid Shrimp		1.1
1	Walleye Pollock	*Theragra chalcogramma*	36.1
2	Flathead Sole	*Hippoglossoides elassodon*	25.5
3	Arrowtooth Flounder	*Atheresthes stomias*	4.8
4	Tanner Crab	*Chionoecetes bairdi*	3.8
5	Pacific Cod	*Gadus macrocephalus*	2.9
6	Halibut	*Hippoglossus stenolepis*	2.5
7	Sculpin	Family Cottidae	1.9
8	Searcher/Ronquil	Family Bathymasteridae	1.5
9	Dungeness Crab	*Cancer magister*	0.9
10	Pink Shrimp	*Pandalus borealis*	0.9
11	Skate	Family Rajidae	0.7
12	Sea Star	Phylum Echinodermata	0.7
13	Weathervane Scallop	*Patinopecten caurinus*	0.7
14	Yellowfin Sole	*Limanda aspera*	0.6
15	Eelpout	*Lycodes* species	0.4
16	Eulachon	*Thaleichthys pacificus*	0.3
17	Dover Sole	*Microstomus pacificus*	0.2
18	Other Shrimp	*Crangon, Eualus, Lebbeus, Sclerocrangon*	0.2
19	Coonstripe Shrimp	*Pandalus hypsinotus*	0.2
20	Alaska Plaice	*Pleuronectes quadrituberculatus*	0.1
21	Prickleback	Family Stichaeidae	0.1
22	Hermit Crab	Family Paguridae	0.1
23	Pacific Herring	*Clupea pallasi*	0.1
24	Humpy Shrimp	*Pandalus goniurus*	<0.1
25	Snail	Orders Mesogastropoda/Neogastropoda	<0.1
NR	Other Animals	Included 14 species this tow.	0.1
NR	Debris		14.8
	Total		100.0

NR = Not Ranked

Appendix M. Species biomass composition ranking in the East Closed Stratum during the Kachemak Bay trawl shrimp survey, 1997.

Rank	Common Name	Species Name	Percent
	Total Fish		67.4
	Commercial Pandalid Shrimp		3.5
1	Walleye Pollock	*Theragra chalcogramma*	28.1
2	Flathead Sole	*Hippoglossoides elassodon*	15.1
3	Pacific Halibut	*Hippoglossus stenolepis*	4.3
4	Pacific Cod	*Gadus macrocephalus*	3.2
5	Sea Anemone	Order Actiniaria	3.0
6	Starry Flounder	*Platichthys stellatus*	3.0
7	Pink Shrimp	*Pandalus borealis*	2.9
8	Skate	Family Rajidae	2.2
9	Arrowtooth Flounder	*Atheresthes stomias*	1.6
10	Alaska Plaice	*Pleuronectes quadrituberculatus*	1.2
11	Tanner Crab	*Chionoecetes bairdi*	1.1
12	Sculpin	Family Cottidae	1.0
13	Sponge	Phylum Porifera	0.9
14	Yellowfin Sole	*Limanda aspera*	0.7
15	Eulachon	*Thaleichthys pacificus*	0.6
16	Rock Sole	*Lepidopsetta bilineata*	0.4
17	Coonstripe Shrimp	*Pandalus hypsinotus*	0.4
18	Other Shrimp	*Crangon, Eualus, Lebbeus, Sclerocrangon*	0.3
19	Tomcod	*Microgadus proximus*	0.3
20	Eelpout	*Lycodes* species	0.2
21	Humpy Shrimp	*Pandalus goniurus*	0.2
22	Searcher/Ronquil	Family Bathymasteridae	0.2
23	Sea Star	Phylum Echinodermata	0.1
24	Other Crab	Infraorder Brachyura/Anomura	0.046
25	Pacific Herring	*Clupea pallasi*	0.032
26	Dungeness Crab	*Cancer magister*	0.025
NR	Other Animals	Included 8 species this tow.	0.08
NR	Debris		28.8
	Total		100

NR = Not Ranked

Appendix N. Species biomass composition ranking in the Tutka Bay and Sadie Cove stations during the Kachemak Bay trawl shrimp survey, 1997.

Rank	Common Name	Species Name	Percent
	Total Fish		95.5
	Commercial Pandalid Shrimp		0.3
1	Flathead Sole	*Hippoglossoides elassodon*	38.7
2	Walleye Pollock	*Theragra chalcogramma*	27.7
3	Sculpin	Family Cottidae	15.1
4	Arrowtooth Flounder	*Atheresthes stomias*	3.7
5	Yellowfin Sole	*Limanda aspera*	3.2
6	Tanner Crab	*Chionoecetes bairdi*	2.8
7	Alaska Plaice	*Pleuronectes quadrituberculatus*	1.2
8	Eelpout	*Lycodes* species	1.0
9	Giant Wrymouth	*Delolepis gigantea*	0.4
10	Red King Crab	*Paralithodes camtschatica*	0.3
11	Sablefish	*Anoplopoma fimbria*	0.3
12	Other crab	Infraorder Brachyura/Anomura	0.2
13	Pink Shrimp	*Pandalus borealis*	0.2
14	Rock Sole	*Lepidopsetta bilineata*	0.2
15	Sea Star	Phylum Echinodermata	0.2
16	Rex Sole	*Glyptocephalus zachirus*	0.1
17	Sea Football	*Cucumaria fallax*	0.1
18	Starry Flounder	*Platichthys stellatus*	0.1
19	Dover Sole	*Microstomus pacificus*	0.1
20	Coonstripe Shrimp	*Pandalus hypsinotus*	0.1
21	Pacific Tomcod	*Microgadus proximus*	<0.1
22	Prickleback	Family Stichaeidae	<0.1
23	Sea Anemone	Order Actiniaria	<0.1
24	Other Shrimp	*Crangon, Eualus, Lebbeus, Sclerocrangon*	<0.1
25	Majestic Squid	*Berryteuthis magister*	<0.1
26	Poacher	Family Agonidae	<0.1
27	Pacific Herring	*Clupea pallasi*	<0.1
28	Hermit Crab	Family Paguridae	<0.1
29	Humpy Shrimp	*Pandalus goniurus*	<0.1
NR	Debris		4.1
			100.0

NR = Not Ranked